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Understanding Hosting Communities as a Stakeholder in the Provision of Urban Infrastructure to Displaced Populations

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Understanding Hosting Communities as a Stakeholder in the Provision of Urban Infrastructure to Displaced Populations

by

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Dissertation

Presented to the Faculty of the Graduate School of

The University of Texas at Austin

in Partial Fulfillment

of the Requirements

for the Degree of

DOCTOR OF PHILOSOFY

The University of Texas at Austin

August 2020

Dedication

Dedicated to my beloved wife, Francia Tapia, for your unwavering support and love.

Acknowledgements

I would like to thank my supervisor, Kasey Faust, for the advice, support, and permanent encouragement to reach my full potential as a researcher and as a person. I feel really fortunate to have worked these four years in the CEPM program with Dr. Kasey Faust. I really enjoyed our group meetings, learning the value of supporting others, and being supported by others. I always looked forward to our weekly meetings, having these meeting with you has been one of the most enriching academic experiences of my life. You are an example for your students, as a researcher and as a person. I hope someday I can become as good as an advisor as you were with me.

I would like to thank my dissertation committee members Dr. Jessica Kaminsky, Dr. Fernanda Leite, Dr. James O'Connor, Dr. Keri Stephens, for your time and for providing valuable recommendations to complete my dissertation work.

I am also grateful to Dr. Faust's research group from their advice, feedback, and friendship: Khalid Osman, Euijing Yang, Julie Faure, Kelsey Abel, Amal Bakchan, Lauryn Spearing, and Michaela Lapatin. It has been an excellent experience to collaborate with you all and exchange different opinions about the world.

The material for this dissertation is based upon work supported by the National Science Foundation under Grant No. 1624409 and 1624417; and by Conicyt/ANID under the program Becas Chile Grant No. 72170369. Additionally, I would like to acknowledge the support from Departamento de Obras Civiles from Universidad Tecnica Federico Santa Maria through the Faculty Development Scholarship provided by the Chilean Fulbright Commission.

Ultimately, I would like to say thank you to my wife, Francia, for your permanent support and love during our time here in the United States. I will be forever in debt with you for all the sacrifices you have done for us.

Abstract

Understanding Hosting Communities as a Stakeholder in the Provision of Urban Infrastructure to Displaced Populations

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The University of Texas at Austin, 2020

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As the world's population has shifted to urban areas, so has the accommodation of displaced populations due to natural disasters, violent conflicts, or persecution. Accommodating those displaced in the urban context places challenges on engineers and decision-makers not only in terms of responding to the unexpected infrastructure needs from displaced persons but also ensuring that the infrastructure provided to pre-existing residents of hosting communities are not negatively impacted. Understanding how communities hosting displaced persons react to the disruptions of providing infrastructure to those displaced is fundamental for engineers and decision-makers to provide sustainable infrastructure under such a disaster scenario. This dissertation seeks to understand how hosting communities responded to the disruptions of displaced persons due to the European Refugee Crisis during 2015 and 2016. To accomplish this, statistical and qualitative analyses were coupled to analyze data gathered from a survey deployed in 2016 to local German residents to understand contextual factors influencing hosting

communities' perceptions toward disruptions from displaced persons on urban infrastructure and alternatives to provide infrastructure. Further, hosting communities' perceptions toward infrastructure alternatives were simulated and compared with decisions made by local authorities regarding alternatives to provide infrastructure as an incremental step toward the integration of hosting communities as stakeholders. This dissertation reveals that local authorities and decision-makers in charge of the provision of urban infrastructure to displaced populations should account for hosting communities as a valid stakeholder. The hosting communities' perceptions indicate that infrastructure alternatives may have different levels of support or opposition depending on local context. This reinforces the importance to plan and develop alternatives that are in conversation with the interests and concerns from hosting communities' residents, which can minimize potential sources of public opposition from hosting communities.

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CHAPTER 1. INTRODUCTION

1.1. Motivation and Research Objectives

In recent decades, the world has seen a trend of people living in urban areas. As of 2018, 55% of the world's population resides in urban areas, while in 1950, 30% of the population was urban; this trend is expected to continue (UN 2018; World Bank 2019). The distribution of urban population places technical and managerial challenges for urban infrastructure systems as well as to institutions, engineers, and decision-makers who manage such systems.

One driver of urbanization has been the displacement of population. Displacement may occur for a variety of reasons, such as natural disasters, violent conflicts, or persecution. For example, primarily due to the instability in the Middle East, the number of displaced people has risen from roughly 42 million in 2011 to more than 68 million in 2017 globally, the largest numbers seen since the World War II (UNHCR, 2018). Interestingly, the accommodation of displaced persons within hosting communities has evolved from primarily rural accommodation—e.g., refugee camps—to accommodations within urban centers; as of 2017, a majority of displaced people worldwide were living in urban environments (Brandt 2019; UNHCR, 2016b; UNHCR, 2018; World Bank, 2017).

Consequently, the provision of infrastructure services to displaced persons no longer occurs in isolation from local, hosting communities, but in conjunction with the existing built environment. The large influx of displaced persons represents a cascading disruption to the existing urban infrastructure in hosting communities that would have otherwise been unimpacted (Dawadi and Ahmad, 2013; Faust and Kaminsky, 2017; Shi et al., 2016). When population growth in urban areas is unexpected and lacks front-end planning, the additional demands can overload existing urban infrastructure systems and may impact the services provided to pre-existing and additional users alike (Varis et al., 2006). Understanding how hosting communities perceive this disruption and alternatives to provide infrastructure to displaced persons may assist decision-makers to provide sustainable infrastructure services in hosting communities.

This dissertation seeks to understand the role of German hosting communities as a stakeholder involved in the provision of urban infrastructure—specifically water and wastewater infrastructure—to displaced populations. Ultimately, this work can help to mitigate any potential negative sentiment and leverage community-supported alternatives to provide critical infrastructure in such a migratory disaster context.

Chapters 2 and 3 address how hosting communities perceived the impact of displaced persons on urban infrastructure systems, and how different alternatives to provide urban infrastructure to displaced persons were perceived, respectively. Chapter 4 proposes a framework for the decision-making process of the provision of infrastructure to displaced populations that includes hosting communities as a stakeholder in such a process. This chapter explores the existing misalignment between decision-made by authorities to provide infrastructure to displaced persons and how communities perceive such alternatives based on a modeling framework. Finally, Chapter 5 summarizes the theoretical and practical contributions of this dissertation and discusses potential avenues for future research that could build upon the findings discussed in this dissertation.

1.2. Research Methods Overview

1.2.1. Data Collection Process About German Hosting Communities

Enabling this research is a survey deployed to the German public in August 2016, during the peak influx of displaced peoples into the European Union (Eurostat, 2016; Eurostat, 2017), and transcripts from interviews with stakeholders involved in the accommodation of displaced persons in Germany. The survey aimed to assess attitudes toward and perceptions of the incoming displaced persons, their impacts on infrastructure systems, and alternatives to provide infrastructure services. The survey included closed-ended questions presented using a Likert scale and open-ended questions. The final sample of valid survey responses included 416 responses.

Germany was chosen to conduct this research due to the large influx of population that received during the commonly referred refugee crisis in Europe. In 2015 and 2016 combined, approximately 2.4 million first-time asylum seekers sought refuge in countries from the European Union, of which nearly 50% were registered in Germany (Eurostat 2016; Eurostat 2017). This population influx was primarily housed in urban environments, placing additional demands on the urban infrastructure systems from hosting communities. With such a high magnitude of incoming persons, Germany presented a unique opportunity to explore the impacts of a rapid and sudden influx of displaced persons on existing urban infrastructure systems that are geographically independent from the natural or human-made disaster.

1.2.2. Survey Analysis And Statistical Modeling

Survey responses were analyzed using nonparametric statistical tests of independence and statistical modeling. In Chapter 2, questions related to the perceived impact of incoming displaced persons were analyzed to assess whether perceptions from hosting communities differed across geographic scales. Additionally, geographic and socio-demographic attributes from hosting communities were identified that make them more or less likely to perceived displaced personas as a disruption for their urban infrastructure systems. In Chapter 3, geographic and socio-demographic attributes from hosting communities were identified that made them more or less likely to support specific alternatives to provide infrastructure to displaced persons.

Qualitative analysis was performed on open-ended questions in Chapter 3. The qualitative analysis provides insight into how hosting communities perceive displaced persons ought to be provided with water and wastewater services used to supplement the quantitative analysis. The mixed-method research design—quantitative and qualitative—allowed to compensate for each method's weakness (Neuman 2011). Coupling the quantitative approaches with qualitative analysis increases the robustness of the research findings by providing a multi-dimensional assessment of the subject achieved through synergy (Fellows and Liu 2015).

1.2.3. AGENT-BASED MODELING

A framework using agent-based modeling (ABM) was proposed in Chapter 4. The framework allows for integrating two types of stakeholders involved in or impacted by the process of providing urban infrastructure to displaced persons, namely local authorities—e.g., decision-makers, utility engineers and managers—and residents from hosting communities. The proposed framework allows to study the decision-making process followed by local authorities while also understanding public perceptions regarding infrastructure alternatives to provide such infrastructure to displaced persons.

CHAPTER 2. PUBLIC PERCEPTIONS FROM HOSTING COMMUNITIES: THE IMPACT OF DISPLACED PERSONS ON CRITICAL INFRASTRUCTURE

This chapter has been reproduced with minor changes from:

Araya. F, Faust. K, Kaminsky. J. Public Perceptions from Hosting Communities: The Impact of Displaced Persons on Critical Infrastructure. *Journal of Sustainable Cities and Society*. Volume 48, July 2019, 101508. https://doi.org/10.1016/j.scs.2019.101508

Contributions: Felipe Araya performed investigation, data analysis, writing of the original draft, validation and visualization. He also performed, with the help of the two co-authors, the conceptualization of the study, methodology development, review and editing of the manuscript.

Abstract: In 2016, there were over 65 million people around the world forcibly displaced. Such a massive displacement of population creates challenges for host communities trying to provide them infrastructure services. For example, no front-end planning or construction may be possible given the unexpected nature of disaster events. This study assesses host communities' public perceptions, at both city and national scales, of displaced persons' impacts on water, wastewater, and transportation systems. This study draws on data gathered through a survey deployed in August 2016 to the public in Germany, where approximately 722,000 people sought refuge the same year. Statistical analyses show that heterogeneous drivers of public perceptions include both geographic and demographic parameters. Nonparametric tests reveal that the public perceived the impact on infrastructure systems similarly within city and national scales, but differently across. It is hypothesized here that the difference is due to residents perceiving this group of infrastructure systems as a system-of-systems that is part of their built environment. If we understand how hosting communities perceive the impacts of

displaced persons, we may gain insights into perceived infrastructure disruptions. With such insights, we may assist policy-makers and engineers in planning locally acceptable infrastructure alternatives to integrate displaced population.

Keywords: Public perceptions; displaced persons; statistical analysis, water, wastewater, and transportation systems

2.1. Introduction

In 2016, 65.6 million people around the world were forcibly displaced (including internally displaced persons, asylum seekers, and refugees). Compared to five years earlier (2011) this was a 50% increase (UNHCR 2017). Of these 65.6 million, approximately 25.3 million were either refugees or asylum seekers (UNHCR 2017). Historical drivers of displacement include, but are not limited to, persecution, violence, and natural disasters. Recent events resulting in mass displacement include the Syrian Arab Republic War (UNHCR 2015a), the Iraq War (UNHCR 2015b), and, in the United States, Hurricanes Katrina (Sterett 2011; Mitchell et al., 2012) Irma, and Harvey (Hendry and Regan 2017; Sullivan et al., 2017).

In 2016, and primarily due to instability in the Middle East, the European Union (EU) received a record 1.2 million first-time asylum applications. Receiving most of these was Germany, the context of this study. It received 722,000 applications (approximately 60%; Eurostat 2017). In 2017, the number of displaced persons continued to rise, reaching approximately 68.5 million people (UNHCR 2018). In the EU, Germany again received the most applications (approximately 200,000; Eurostat 2018).

These asylum seekers were distributed throughout the nation, and thereby to different infrastructure systems using a quota system that is “calculated at the federal level on an annual basis by the Federation-Länder Commission" (BAMF 2017). For each federal state, asylum seekers are distributed based on a system that weights the total population by one-third and the tax revenue by two-thirds (Katz and Garrelts 2016). The distribution system has some disadvantages; it fails to account for a region's population density, housing availability, or the fact that "individuals may attempt to settle in regions other than those assigned" (Katz and Garrelts 2016, p.11). As such, the system is unable to capture potential secondary migration patterns. Similarly, the system fails consider the status or capacity of the existing infrastructure systems that serve those regions, assuming that they will be able to provide infrastructure services to both, existing and incoming new users.

It is important to note that the challenge of receiving displaced persons is not isolated to the EU, and is likely to become a global issue, one that will call for innovative solutions (Dabaieh and Alwall 2018). For instance, in 2015 the United States received 262,000 first-time asylum applicants, of whom more than 50% were from Mexico or countries in Central America (UNHCR 2017). In other words, the technical issues involved in hosting displaced persons such as accommodating increased demand for water and housing resources or the costs of additional infrastructure are globally and domestically relevant (UNHCR 2016; UNHCR 2017; UNHCR 2018).

Any rapid influx of population creates additional and unexpected demands on infrastructure systems. These demands could impact the services received by existing end users (Varis et al., 2006) as well as the displaced population. Authors of infrastructure assessment often focus on the physical components of infrastructure systems. Yet what populations value most about these systems are the services they provide (Little 2002). It is critical then to understand how users perceive changes in their infrastructure services caused by displaced persons in addition to understanding the technical impact they have on infrastructure systems. Another challenge in this regard is distinguishing between how end users perceive changes in the infrastructure services and how experts assess those infrastructure services (de Franca Doria et al., 2005; de Franca Doria et al., 2009). In the case of water quality, while a population's water supply might meet technical standards, residents may reject it due to aesthetic attributes (Jardine et al., 1999).

Population growth and urbanization have caused residents to perceive impacts on such infrastructure services as water, wastewater, and transportation infrastructure systems (Islam et al., 2014). In fact, residents were highly dissatisfied with the perceived changes. What is interesting, though, the levels of dissatisfaction were not distributed homogeneously among the dwellers, as such, within the same city, residents from different locations manifested different levels of dissatisfaction (Islam et al., 2014). However, a gap exists in understanding how a disruption caused by hosting displaced persons might influence public perceptions of the impacts such hosting communities has on multiple infrastructure systems—e.g., water, wastewater, and transportation. This topic is becoming increasingly important due to a rise in the frequency and severity of disasters (Bier 2017; Faust and Kaminsky 2017; Mitchell et al., 2012; Sterett 2012). Consider, for instance, the following: In 2015, approximately 850,000 refugees arrived in Greece (OPRS 2019); in 2017 after Hurricane Maria over 130,000 people arrived in Florida (Sutter 2018); in 2018 after California's most destructive forest fire ever, approximately 50,000 displaced people arrived in—towns near Campfire (Philips 2018); between 2015 and 2018 approximately three million Venezuelans migrated to nearby Latin American (UNHCR 2019).

This paper contributes to the limited literature dealing with the impact, actual and perceived, of displaced populations on infrastructure systems. The paper's focus is on the water, wastewater, and transportation systems because this study examines the impact on critical infrastructure systems whose services community members share. The way individuals interact with these systems, in real time, can cascade to impact the level of service for other users.

In addition to the influence of population dynamics on public perceptions of infrastructure projects (e.g., wind energy projects, coal, and nuclear power plants), these perceptions are also influenced by the perceived costs (e.g., environmental harm; Ansolabehere and Konisky 2009; MIT 2003; MIT 2007; Valentin et al., 2017). If a community perceives an infrastructure project to be a cost, they are likely to oppose it. Interestingly, infrastructure projects facing public opposition have faced different risks such as negative impacts on projects' budget, schedule, and scope (DiCristopher 2017; Hurlimann and Dolnicar 2010; Valentin et al., 2017). Therefore, the way communities perceive potential costs from developing infrastructure projects influences their public attitudes toward such projects.

These perceptions then may complicate management aspects of infrastructure projects, which given their size and scope, are traditionally considered complex projects. Therefore, if project managers want to mitigate challenges posed by public opposition, they need to include end-user perceptions while managing infrastructure projects and systems (Knoeri et al., 2016; Valentin et al., 2017). To do this, project managers need to have a grasp of public perceptions in the aggregate. Moreover, they need to understand the locational and socio-demographic drivers (e.g., location, age, income) of heterogeneity in perceptions that may trigger the support or opposition of infrastructure projects in communities.

The assessment of public perceptions from hosting communities is done in the context of place attachment theory. Place attachment theory suggests that when a community is disrupted their residents may develop negative sentiments toward the disruptor (Devine-Wright 2009). Place attachment literature focused on the effects of disruptions at the household or neighborhood level (Lewicka 2011). When it comes to assessing the influence of disruptions at higher scales of analysis such as at city or national level, there is a gap in the literature. This study aims to explore the perceived impact of hosting communities on infrastructure systems at the city and national scales. The study provides avenues with which researchers can target information on key socio-demographic groups, gather feedback from those opposing projects, and tailor alternatives to fit the unique needs and culture of each project context. Furthermore, researchers can use public perceptions to explore the effectiveness of existing systems and identify locations that call for infrastructure alternatives.

Given this research context and the critical need to provide infrastructure services to displaced populations, this study poses the following questions: How do public perceptions of infrastructure systems—water, wastewater, and transportation—vary according to system and across city and national levels? What are the drivers of such perceptions? How does the perceived impact of displaced persons vary by location and scale (city versus country)?

2.2. Literature Review

In this literature review, we frame population displacement as an instance of extreme population dynamics caused by a disaster event. When displaced populations move to a geographically distinct infrastructure system, there are significant technical implications for the recipient system due to increased loads. If infrastructure managers fail to manage these changes, real or perceived reductions in levels of service may result. To service incoming displaced persons, cities may propose infrastructure projects, but the public, already dissatisfied with their service, may protest these projects or even try to negatively impact the integration of the displaced population. Researchers have yet to fully study this important type of secondary disaster impact and its consequences on infrastructure systems.

2.2.1. POPULATION DYNAMICS AND INFRASTRUCTURE SERVICES

Extreme population dynamics present a challenge for infrastructure systems. The technical capacity of infrastructure systems may be overburdened, ultimately affecting the level of service provided to end-users (Varis et al., 2006). Displacement-induced growth is certainly different from typical population growth, which occurs more slowly and predictably. Still, there are similarities due to increases in the loads placed on the existing infrastructure systems that provide insights into the impacts of the more extreme cases. For example, water and wastewater infrastructure may be strained as they are pushed to meet water demands (Dawadi and Ahmad 2013); municipalities; ability to provide sanitation and water services may be constrained by limited water resources (Van der Bruggen et al., 2010). Previous studies of transportation systems have also identified challenges imposed by population dynamics such as traffic congestion (Kolankiewicz et al. 2015) and growth in required maintenance activities (Asoka et al. 2013). Overall, these studies have shown that infrastructure managers must contend with a variety of uncertainties when coping with population dynamics (Zeferino et al. 2012). And post-disaster population displacement is no exception. However, little research has been done on the impact of hosting a sudden population influx on infrastructure systems from hosting communities.

2.2.2. Disasters Events and Construction

Researchers have assessed reconstruction, recovery, and resiliency aspects of construction projects in such disaster scenarios as earthquakes or typhoons (e.g., Sun and Xu 2010; El-Anwar and Chen 2012; Opdyke et al., 2017). These previous studies may be divided into two categories: (1) literature assessing the impact of the disaster at the same location of the disaster, and (2) cascading impacts of the disaster on locations geographically distinct from the disaster.

Research from the former group has focused on reconstruction projects and primarily on three areas: factors influencing the performance of the projects (e.g., Johnson et al., 2006), optimization of resources during a reconstruction project (e.g., Orabi et al., 2009), and interaction among resources and stakeholders (e.g., Hwang et al., 2014). Previous studies that investigated factors affecting reconstruction projects assessed the influence of different organizational and technical systems in housing projects. Johnson et al. (2006) found that the performance of reconstruction projects is influenced by the organizational design of the project teams and programs. Project managers should consider these organizational aspects to be as important as the technical design of the reconstruction project. Other studies developed models to estimate the time and cost associated with the reconstruction project after an earthquake (Sun and Xu 2010). Hwang and colleagues (2016) modeled uncertain conditions of the facility restoration-planning activities.

A second aspect of previous research has concerned optimizing resources during reconstruction projects. Orabi et al. (2009) studied a recovery-planning model for a transportation network. The authors used a multi-optimization model to minimize the performance loss and reconstruction costs while facing limited resources during the planning of the recovery project. El-Anwar et al. (2009) considered the evaluation of the housing´s configuration to maximize the sustainability aspects of housing reconstruction projects. Hosseini et al. (2016) studied the location of post-disaster projects in urban areas. The authors found that decision makers may optimize the location based on variables such as the cost or building methods. El-Anwar and Chen (2012) proposed another technique—considering displacement distance for temporary housing projects to optimize a displaced family's needs under budgetary constraints.

The third segment of this literature—the interaction among resources and stakeholders—has focused on the role government plays in recovery efforts. Hwang et al. (2014) highlighted the fundamental role governments play during the design of recovery plans. Similarly, Opdyke et al. (2017) studied the value of information in recovery efforts. These authors found that the most common resource shared under disaster conditions is information. They also reaffirmed, consistent with findings from Hwang et al. (2014), how central a role government' agencies play in recovery. Arneson et al. (2017) examined information deficits in post-disaster situations and its role among community stakeholders. The authors found that information deficits fall into five categories, including stakeholder coordination, data management, and social disengagement.

In contrast to the plethora of resarch cited above, there is limited research on the cascading effects of a response that is geographically distinct from the location of the disaster. In the context of the resiliency of water and wastewater systems, Faust and Kaminsky (2017) leveraged knowledge from experts, to find that disaster migration poses challenges to the provision of infrastructure services to hosting communities. One obstacle to providing new infrastructure services to displaced populations was found to be mustering support from hosting communities to provide such services. Disaster migration is of course unexpected and typically lacks front-end planning (Faust and Kaminsky 2017). Given this gap in the literature, this paper examines then impact that displaced persons have on hosting communities' perceptions of water, wastewater, and transportation infrastructure services, in the context of disaster response that is geographically distinct from the primary disaster event.

2.2.3. Stakeholders and Construction Projects

When it comes to building and infrastructure projects, the construction engineering literature has long recognized the importance of interactions between stakeholders as well as their perceptions. Previous research has assessed the impact of stakeholders on project management (e.g., Herazo and Lizarralde 2016; Olander 2007), the role of stakeholders in contributing to the uncertainty of infrastructure projects (e.g., Ward and Chapman 2008), and stakeholder roles in achieving sustainable civil infrastructure systems (e.g., Hendricks et al., 2018; Mostafa and El-Gohary 2014; Prouty et al., 2017). Olander (2007) proposed an approach to evaluating the needs and expectations of stakeholders regarding housing projects. To avoid reactive management and the making of ill-informed decisions, Olander (2007) highlighted the need to proactively assess stakeholder views. Finally, Olander suggested the assessment of stakeholder management across different stages in the execution of construction projects. Ward and Chapman (2008) stated that a major source of uncertainty in projects are stakeholder roles, and these must thus be clearly defined. Mostafa and El-Gohary (2014) proposed a model to evaluate the collective benefits of infrastructure project alternatives for stakeholders. They proposed a plan to integrate participatory actions into the decision-making process. Leung et al. (2013) studied the relationship between stakeholders' power, conflict, interest, and satisfaction with a project. These authors found that conflict among stakeholders, as well as the level of final satisfaction with the project, are influenced by the power and interest held by stakeholders. Concerning the engagement process of stakeholders in construction projects, their engagement prior to the decision-making process has been crucial for projects success (Eschenbach and Echenbach 1996; Li et al., 2013; Li et al., 2018; Valentin et al., 2018). Moreover, incorporating stakeholders impacted by construction projects during the early stages helps project implementation go smoothly (Yang and Shen 2014).

In summary, these studies demonstrate that when project managers fail to account for or misunderstand the role stakeholders they face greater challenges. Indeed, the efficacy and successful completion of a project are associated with the perceptions and attitude of the stakeholders impacted. As such, integrating public perceptions into project decision-making has become an increasingly important strategy used to support project success and minimize public protest.

2.2.4. PUBLIC PERCEPTIONS AND PROJECT PROTEST

For engineers, the level of service received by end users is defined by technical metrics such as water pressures or traffic congestion. End users themselves, however, often take no account of the metrics focusing instead on changes in levels of service (Little 2002; Yang and Faust 2019). Examples of these changes could be a drop in water pressure, a difference in taste of tap water, or longer commutes. When service has changed, regardless of whether it is within the acceptable levels set by regulatory standards or utility expectations, complaints (or increased satisfaction, if these changes are improvement) arise.

Hosting displaced persons and the related increased demands for infrastructure services may cause temporary or a permanent change in the infrastructure systems. Regardless of the time frame, though, the sudden arrival of displaced persons creates immediate and increased demands for infrastructure services. These new demands may have positive or negative effects on infrastructure services depending on a variety of technical factors and responses (Faust and Kaminsky 2017). As such, decision makers tasked with providing displaced persons infrastructure services must also ensure the hosting communities' services are not negatively impacted (e.g., decreasing the level of quality of received service or the end users' level of satisfaction with the system). By incorporating end-user perceptions into the management of infrastructure services, potential opposition that compounds these challenges may be mitigated by decision makers (Knoeri et al. 2016; Valentin et al. 2017).

It is well established that public opposition poses risks for infrastructure projects, potentially impacting projects' budget, schedule, or execution, and therefore it is necessary to include public opinion in the planning of building infrastructure projects (Jiang et al. 2016; Valentin et al., 2018). In 2015, for instance, the Keystone pipeline project in the United States faced major public opposition, temporarily forcing the project to come to a halt (DiCristopher 2017). Public opposition can impact all types of civil infrastructure systems. It has impacted water infrastructure projects (e.g., halting a proposed project to enlarge the water supply system in Australia; Hurlimann and Dolnicar 2010); transportation infrastructure, notably transit stations in Canada (Kinawy et al., 2017). Public opposition has impacted industrial, mining, and dam projects (e.g., stopping a mining project in Peru due to water pollution; Schneider 2017) as well as energy sector projects (e.g., overturning environmental permits in Chile for five dams planned for electric generation; Howard 2014). Implementing infrastructure alternatives over the objections of the public is likely to be slow and inefficient (Faust et al. 2016). In the context of water and pipeline infrastructure projects, the legal and political conflicts arising from projects are driven by contextual (e.g., country of execution, equity of host country, size of the project) and stakeholder characteristics (Boudet et al., 2011).

The factors that sustain opposition toward a project were the subject that Teo and Loosemore (2011) developed a model to study. The authors found that continuity of social opposition is a complex dynamic process, that if better understood, could be beneficial for communities, government, and firms related to the projects. Participatory processes have thus become increasingly important in projects (Di Maddaloni and Davis 2017; Teo and Loosemore 2017; Yang et al., 2018). Still, achieving meaningful public participation in infrastructure projects is difficult, partially because public perceptions vary across populations and locations. While aggregated measures of perceptions provide insight into gauging where most of the public is, they do not provide insight into the factors influencing these perceptions. This loss of granularity can negatively impact the management of a system or the alternatives considered in communities by giving rise to the assumption that the average represents the distribution. For example, previous studies have identified how geographic characteristics, influenced by the contextualized surrounding of residents, impact their respective perception towards specific infrastructure alternatives and the levels of infrastructure services received (Faust et al. 2016; Faust et al. 2018).

Similarly, socio-demographic characteristics have been found to impact perceptions of infrastructure. Numerous studies have explored the relationship between socio-demographic and behavioral parameters, and perceptions. Researchers have examined, for example, the impact of demographic characteristics (e.g., age, gender) on pro-environmental behavior regarding climate change and physical infrastructure measurements such as highway roughness (Chen et al. 2011; McCright 2010; Shafizadeh and Mannering 2006). Researchers have also studied the relation between income and educational level regarding concern about the environment (Klineberg et al. 1998), how the source of the news impacts economic policies (Gilens 2009), and how policy preference influences public attitudes toward energy security and nuclear power (Corner et al. 2011). Although research on perceptions typically provides cross-sectional representations, perceptions are dynamic, and change with new information, and events. Still, in the context of public policies and decision-making, there is evidence that even cross-sectional insights into public perceptions can identify (and potentially minimize) sources of opposition due to the intrinsic interrelation between policy and public perceptions (Burstein 2003; Soroka and Wlezien 2004; Gray et al. 2004). For example, Jorgensen et al. (2009) explored the impact of public voice on water-utility initiatives, finding that the level of trust of end users may play a fundamental role in water consumption and can be used by water utilities to develop water consumption initiatives. Other studies have found that end users perceptions and trust in the water utility provider impacts their water consumption and perceived quality (Doria 2006; Doria et al. 2009).

Another potential influence of variation in the study of public perceptions in hosting communities is the use of different geographical units of analysis. Previous studies have addressed the potential effects of differing geographical scales, such as the relationships among the scales of interest to resolve a problem within the community, or the influence of the sense of community on the perception of community disruptors. Kingston et al. (2000) stated that when the geographic scale increases in size (e.g., from city to country), a smaller portion of people directly affected by the problem will sustain interest and continue working to resolve the problem. The literature suggests that, from an individual perspective, when people have lived in a place over time, they develop a positive emotional link with it, known as *place attachment* (Clarke et al., 2018; Devine-Wright 2007; Devine-Wright 2009). The development of these feelings of attachment are influenced by attributes such as the length of time in a dwelling (Brown & Perkins, 1992), education (Anton and Lawrence 2014), personal experience with the living environment (Clarke et al., 2018), and perceptions and evaluations of the place (Rollero and De Piccoli 2010). Sometimes the concept of the community is more relevant than the individual. Researchers Kasarda and Janowitz (1974) and Perkins and Long (2002) refer to this phenomenon as *community attachment*. Disruptions affecting that location can lead to negative sentiments or opposition toward the disruptors (Devine Wright 2007; Devine-Wright 2009).

Existing literature has reported that residents' perceptions of community disruptions can interact with different levels of place-attachment sentiments. This has occurred in the context of different disruptors such as implementing alternatives to mitigate climate change or urban growth. Such interactions have resulted in communities showing either public support or opposition toward these disruptions on communities (Devine-Wright 2013; Hovelsrud et al., 2018; Verbrugge and van den Born 2018; von Wirth et al., 2016). On the one hand, Devine-Wright (2013) discussed potential negative impacts on place-attachment sentiments due to mitigation alternatives for climate change scenarios, e.g., communities demonstrating limited ability to change or adapt. On the other hand, von Wirth et al. (2016) found that when residents perceived a disruption positively—rapid urban growth—place-attachment sentiments from residents can be strengthened. Similarly, Verbrugge and van den Born (2018) found that the higher the place-attachment sentiments among residents, the more positively they evaluated planned river interventions—e.g., flood safety improvements. Therefore, by accounting for how communities perceive disruptions to their environment, authorities and decision makers may be able to manage and plan for community-supported alternatives to respond to disruptions.

Existing literature has successfully linked community place-attachment sentiments with perceptions of alternatives disrupting their existing environment. Most of this literature has been focused on place attachment at the household or neighborhood level (Lewicka 2011). In the current analysis, we study how, at the city and national scales, hosting communities perceive the impact of displaced persons on water, wastewater, and transportation infrastructure services.

2.3. Methods

To carry out this study, researcher analyzed survey data that included nonparametric tests and statistical modeling. A survey was deployed among a representative sample of the German public to assess public attitudes in hosting communities toward the impact of incoming displaced persons in Germany. The survey approach was selected as research strategy due to its capacity to produce a large amount of data (n = 416) relatively quickly (Kelley et al., 2003), especially when compared with other approaches such as interviews, questionnaires, or focus groups. Importantly, this approach allowed researchers to capture hosting communities' perceptions in 2016, during the peak of the displaced persons' crisis in Europe. However, survey methods preclude interactions with respondents, thus limiting researchers' ability to discover emergent insights from respondents.

This study is focused on the responses to six survey questions that statistically explored whether hosting communities perceived displaced persons to be impacting the water, wastewater, and transportation systems at either or both of the city or national scales.

Researchers also statistically modeled perceptions of each one of the three infrastructure systems at each scale. The modeling was done using an extensive set of locational and socio-demographic parameters to identify the drivers of such perceptions.

2.3.1. Identification of Drivers of Public Perceptions

In this study, we used the locational and socio-demographic characteristics of hosting communities to model the perceived impact of displaced persons in such communities. These characteristics are included as independent variables for the statistical modeling of public perceptions. The locational characteristics are represented by the state of residence (see Table 2.1). This characteristic is included based on the “place attachment theory” (Devine-Wright 2007; Devine-Wright 2009) discussed in the literature review. As such, we hypothesized that specific locations might be statistically significant indicators of public opinion in hosting communities. And, by including locational characteristics, we ensure that the survey results are geographically representative of Germany as well as representative of the distribution of incoming displaced persons (see Table 2.1). Regarding the socio-demographic characteristics, a review of the literature of public perception toward infrastructure projects revealed that socio-demographic characteristics such as age, gender, income level, highest level of education achieved, and the primary source of the news are significant in assessing public perceptions (Chen et al. 2011; Corner et al. 2011; Faust et al. 2016; Gilens 2009; McCright 2010;). As such, we included an extensive set of socio-demographic parameters to identify the drivers of these perceptions in our statistical models (see Table 2.2). Identifying socio-demographic drivers increases the level of granularity in the assessment of public perceptions. If our logic is correct, geographic locations and socio-demographic parameters should appear as significant parameters in the statistical models (see Tables 2.5-2.7). Furthermore, the most relevant parameters should be expected to be recurrent among different statistical models.

2.3.2. Survey Development and Deployment

In August 2016, researchers distributed a survey among the German public to assess the perceptions, awareness, knowledge, and attitudes in hosting communities of the provision of infrastructure services for incoming displaced persons. Of particular interest were six questions intended to assess whether respondents perceived that incoming displaced persons had, during the three years prior (2013-2016), impacted the water, wastewater, and transportation systems at the city scale as well as at the national scale. Within the survey, respondents were asked the following (translated to English below):

"The incoming displaced persons in the past three years have strained my city's water/wastewater/transportation infrastructure," and

"The incoming displaced persons in the past three years have strained Germany's water/wastewater/transportation infrastructure."

Context for the circumstances and information sought were provided at the beginning of the survey, and other questions were asked prior to the questions of interest here. *Strain* in this context was defined as an additional physical demand on the infrastructure systems (i.e., water, wastewater, and transportation) due to incoming displaced persons that consequentially impacted the performance of the system and the service received by the end user/community. For the three systems under study, public perceptions are intended to capture the public and private domains of these systems. For example, transportation infrastructure used by both private vehicles (e.g., roadways) as well as public transit (e.g., rail for local trains, roadways for busses).

Questions were posed on a five-point Likert scale—strongly disagree, disagree, agree, strongly agree, and I do not know. The I-do-not-know option was included to account for respondents not having been aware of the impact on or the performance of the specific infrastructure system in question. A neutral option was not included, so as to force respondents to take a stance and avoid decision paralysis (Krosnick et al. 2002; Barge & Gehlbach 2012). The survey (conducted in German) was electronically deployed by a third party, Qualtrics, LLC (Qualtrics 2016), using a random sample based on geographic quotas to be representative of Germany, not a specific area/region/city in Germany (see Table 2.1). Based on timestamps from the final valid samples, the survey took on average 21 minutes, thus survey fatigue was avoided (Savage and Waldman 2008).

Prior to deployment, the survey was reviewed by eight subject-matter experts with expertise spanning survey development and analyses, infrastructure systems, human-infrastructure interactions, modeling individual and aggregate public perceptions, and German language and culture. The survey was pre-deployed to 15 individuals to assess the correctness of the data collected, German word choice, and accessibility of questions by individuals with limited content knowledge. Notably, the pre-deployed sample was not included in the final sample pool. The survey underwent Institutional Review Board (IRB) review at the University of Texas at Austin and at the University of Washington. All respondents participated voluntarily and were over 18. The first question concerned obtaining consent. Data was kept on passwordprotected laptops by the research team and used for academic purposes. No identifying information such as name or address was collected by the research team.

The final sample consisted of residents from the 16 states in Germany (See Table 2.1). As of the Federal Statistics Office of Germany (Destatis), the total population of targeted states was approximately 82.5 million in 2016 (Destatis 2018a). To obtain a confidence of 95% +/- 5%margin of error, the sample size was calculated as (Fellows and Liu 2015; O'leary 2004; Pack and Devore 2011; Washington et al. 2011):

$$Number\ of\ observations = \frac{(Z_{score})^2 \cdot St.dev(1 - St.dev)}{ME^2} \qquad \text{(Eqn 1)}$$

, where the corresponding z-score for a 95% confidence is 1.96, the margin of error (ME) is 5%, and the standard deviation is 0.5, which provides a conservatively large value for the required sample size (Fellows and Liu 2015; Peck and Devore 2011). Thus, for a representative sample of the German public, there is needed a minimum sample size of 385 valid responses. Notably, the final sample of this study consisted of 416 valid responses spanning 16 states in Germany.

Table 1 shows three components—the distribution, in 2016, of the German population across those sixteen states (Destatis 2018a), the distribution of displaced persons in those same states (BAMF 2017), and finally the distribution of responses from the survey deployed in this study for those sixteen states. The geographic distribution of the survey responses was the primary parameter used to ensure that the sample was representative of Germany and not representative of a single state. The difference between the percentage of population living in a German state and the percentage of survey responses from that state was an average of 1.4%, indicating the sample distribution well represents the German population. Regarding socio-demographic characteristics, the survey sample aligned with the socio-demographic characteristics of Germany (Destatis 2018b). The percentage of males responding to the survey was 54%, while Germany's actual percentage of males in 2016 was 49% in 2016. The percentage of respondents living in a household with two or fewer people was 69%, while 75% of the German population meets this criterion (Destatis 2018b).

Table 2.1. Distribution of German population, distribution of displaced persons allocated, and distribution of survey responses, by German state

State	Percentage of German population (2016)	Percentage of displaced persons allocated by each state (2016)	Percentage of survey responses (2016)
Bavaria	15.7%	15.5%	16.1%
Baden-Württemberg	13.3%	12.9%	10.3%
Berlin	4.3%	5.1%	7.9%
Brandenburg	3.0%	3.1%	3.4%
Bremen	0.8%	1.0%	1.2%
Hamburg	2.2%	2.5%	2.6%
Hesse	7.5%	7.4%	11.5%
Lower Saxony	9.6%	9.3%	7.7%
Mecklenburg-Western Pomerania	2.0%	2.0%	2.4%
North Rhine-Westphalia	21.7%	21.2%	21.6%
Rhineland-Palatinate	4.9%	4.8%	3.8%
Saarland	1.2%	1.2%	1.7%
Saxony	4.9%	5.1%	2.9%
Saxony-Anhalt	2.7%	2.8%	2.6%
Schleswig-Holstein	3.5%	3.4%	2.4%
Thuringia	2.6%	2.7%	1.7%

2.3.3. NONPARAMETRIC TESTS

Questions regarding perceived impact at each scale were measured using an ordinal scale from strongly disagree to strongly agree, with an additional I-do-not-know option. I-do-not-know responses were removed from analysis. Due to the ordinal nature of questions, nonparametric techniques were considered to draw appropriate statistical inferences from the data (McCrum-Gardner 2008; Washington et al. 2011).

At the city scale, researchers used the Kruskal-Wallis test to look for differences in perceived impact on the (1) water, (2) wastewater, and (3) transportation systems (Washington et al. 2011). Next, the authors tested the same hypothesis at the national scale. These tests evaluate the conventional notion of perceived differences between the visible transportation system and the underground, unseen water and wastewater systems. In addition, the authors tested for differences in perceived impact between the city and national scales within each infrastructure type (water, wastewater, transportation). This was tested using the Mann-Whitney test (Washington et al. 2011). For example, the authors compared the perceptions, at the city and national scales, of the impact on the water systems to evaluate whether the two independent populations were statistically different. The wastewater and transportation systems were each tested similarly.

2.3.4. Statistical Modeling using Binary Probit Models

Each of the six questions were collapsed to a binary variable, agree/disagree. The agree component consisted of strongly agree and agree responses; the disagree component consisted of strongly disagree and disagree responses. There is the substantial evidence suggesting that offering no-opinion options while studying attitudes does not enhance data quality (Fowler and Cannell 1996; Krosnick et al., 2002; Krosnick et al., 2005). Hence the I-do-not-know responses were excluded from each question. Responses were collapsed as binary variables to reflect the two possible states of agreeing or disagreeing that there was a perceived impact of displaced persons on the infrastructure systems at the city and national scales. Independent parameters (see Table 2.2) included geographic (e.g., state of residence) and socio-demographic characteristics (e.g., age, gender, educational level). The inclusion of these parameters allowed for discovering subsets of the resident German population that perceived impacts differently from the displaced population.

Best-fit models for all questions were binary probit models with random parameters. Equation 2 is used to predict the level of (dis)agreement with whether incoming displaced persons have impacted the water/wastewater/transportation system at city or national scale.

$$T_n = \beta \cdot X_n + \epsilon_n \quad \text{(Eqn 2)}$$

In Equation 2, β is a vector of the estimated parameters for the outcome n, X_n is a vector of observable or explanatory characteristics for the outcome n such as the geographic or demographic characteristics of the respondents (e.g., state of residence, age, gender, educational level, income level), and ϵ_n is a vector of disturbance effects. Binary probit models (Equation 2) were used to identify the geographic and socio-demographic parameters affecting the likelihood that respondents agree/disagree with each statement under consideration.

$$P_n(agree) = \emptyset(\frac{\beta_{agree} \cdot X_{agree\_n}}{\sigma}) \quad \text{(Eqn 3)}$$

Equation 3 indicates the probability that respondents took one of the two possible outcomes from observation n, where Phi ($\emptyset$) is the standardized cumulative normal distribution. β_{agree} represents a vector of estimated parameters for the agree outcome, and X_{agree_n} is a vector of measured parameters that indicates the discrete outcome for a given observation n. The disturbance effect vector ϵ_n is normally distributed (Washington et al. 2011). Random parameters were incorporated to capture the heterogeneity of the perceived impact across the population, introduced by a density function, $f(\beta|\varphi)$, where φ is a vector of parameters of a specified density function (see Eqn. 4; Washington et al. 2011). All random parameters were normally distributed.

$$P^{rp}{}_n(agree) = \int_X P_n(agree) \cdot f(\beta|\varphi)\, d\beta \qquad \text{(Eqn 4)}$$

Fixed and random parameters reflect the impact of independent variables on the dependent variable (i.e., perceived impact of displaced persons on water/wastewater/transportation at the city and national scales). Random parameters reflect the heterogeneous impact of the parameter across the population (normally distributed marginal effect in this study), while fixed parameters reflect the homogenous impact of the parameter—or fixed marginal effect—across the population.

The method of simulated maximum likelihood with Halton sequence was used to estimate random parameter models. Bhat (2003) demonstrated that using the Halton sequence approach generates an efficient way of drawing values of β from f(β|φ) to compute probabilities and estimate model parameters. In the current study, 500 Halton draws were used to estimate model parameters.

The best-fit model was determined using the Akaike Information Criteria (AIC). The AIC indicates the amount of information lost while using a specific model; a lower AIC indicates a better model (Bozdogan 1987). Marginal effects were used to interpret the results and to quantify the impact of each independent parameter on the dependent variable. The values reported here of marginal effects were the average marginal effect of each parameter across the sample, for a unit change in the independent parameter (Washington et al. 2011). A positive marginal effect indicates an increase in the likelihood that a respondent perceived that displaced persons had impacted water/wastewater/transportation systems at the city and national scales.

Researchers developed, for each question, a probit model with fixed parameters and a probit model with random parameters. Likelihood ratio tests were used to determine the appropriate model, as shown in Eqn. 5 (Washington et al. 2011):

$$\chi^2 = -2[LL(\beta_{fp}) - LL(\beta_{rp})] \qquad \text{(Eqn 5)}$$

where χ^2 is the chi-squared statistic with degrees of freedom (dof) determined by the number of random parameters; $LL(\beta_{fp})$ is the log-likelihood at convergence for the fixed parameters model, and $LL(\beta_{rp})$ is the log-likelihood at convergence for the random parameters model. For all questions, models including random parameters exhibited a better fit than models with fixed parameters. Regarding the perceived impact of displaced persons on the water system at the city scale a χ^2 of 6.20 with two dof indicated a 95% confidence level that the random parameter model was preferred; at the national scale, a χ^2 of 18.48 with two dof indicated a 99.99% confidence level that the random parameter model was preferred. Regarding the incoming displaced persons impacting the wastewater system, at the city scale a χ^2 of 7.20 with two dof indicated a 97% confidence level that the random parameter model was preferred; at the national scale a χ^2 of 14.78 with three dof indicated a 99.8% confidence level that the random parameter model was preferred. For models assessing the impact of incoming displaced persons on the transportation system at the city scale, a χ^2 of 6.01 with two dof indicated a 95% confidence level that the random parameter model is preferred and at the national scale a χ^2 of 12.30 with two dof indicated a 99.8% confidence level that the random parameter model was preferred.

2.3.5. LIMITATIONS

An acknowledged limitation of this study is that public perceptions are dynamic and may change over time with new information, new facts, and social interactions. In contrast, this study is based on a cross-sectional survey, reflecting a specific moment in time. Another methodological limitation is that the survey format minimizes interaction with respondents, obtaining only information that concern the questions; no further information can emerge through interaction with research population as they are likely to when using interview or focus-group methods. Furthermore, this study is focused on Germany, and as such, there are cultural and social factors that may differ from those in other developed countries. Additionally, this study considers only the water, wastewater, and transportation infrastructure systems. Therefore, the findings of this study may not be directly transferable to other infrastructure systems such as the energy sector.

2.4. Results

2.4.1. SURVEY RESULTS

Figures 2.1 and 2.2 show the distribution of responses for whether incoming displaced persons were perceived to have impacted the water/wastewater/transportation systems at the city or national scales, respectively. Table 2 shows the descriptive statistics from the statistically significant parameters from the six best-fit binary probit models. Table 2.3 shows the percentage of responses that agree/disagree that displaced persons have impacted the performance of none of the systems or all of the systems at a city scale and a national scale. Table 2.4 shows the percentage of responses that indicated that displaced persons have impacted the infrastructure systems at the city scale as well as the national scale. For instance, 22.5% of respondents perceived that displaced persons have impacted both the water and the wastewater systems at the city scale.

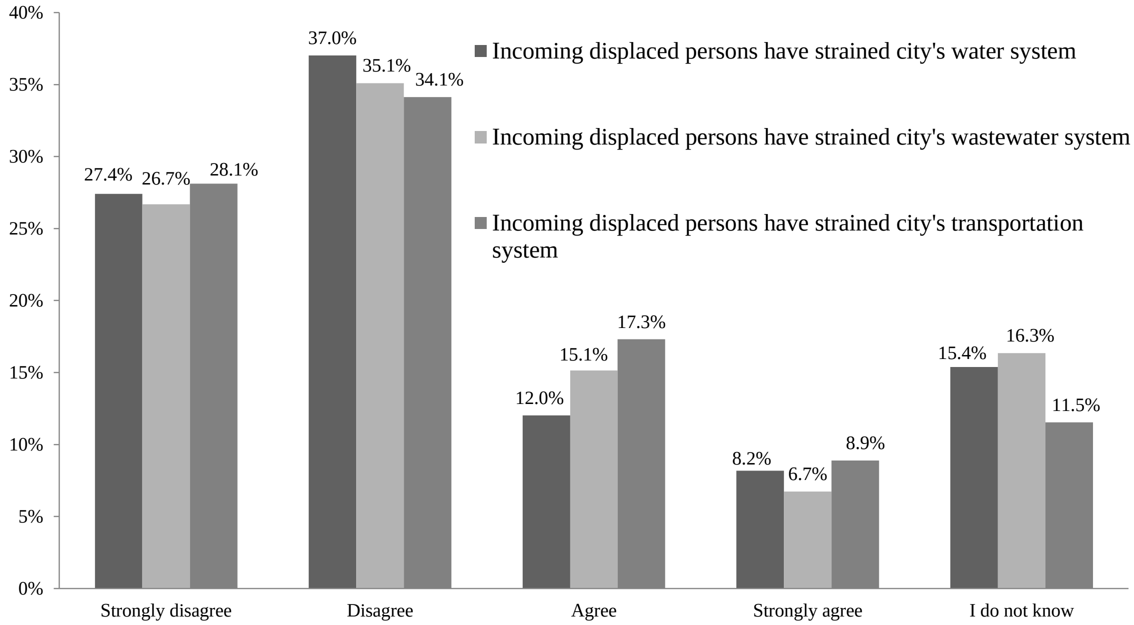

Figure 2.1. Displaced persons in the past three years (2013-2016) have strained the city´s water/wastewater/transportation infrastructure

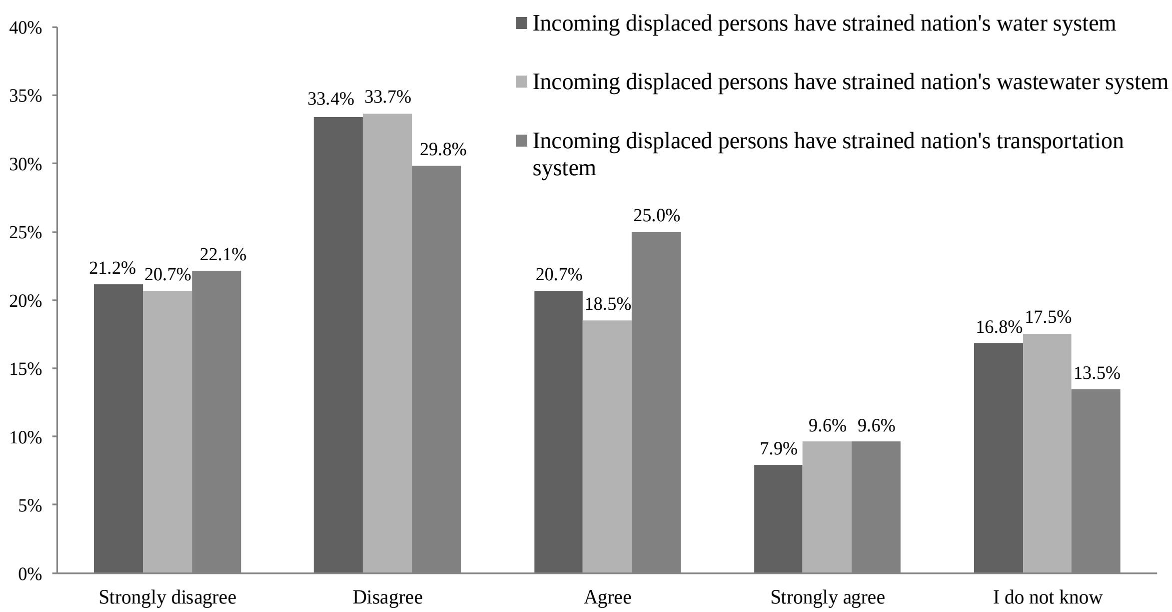

Figure 2.2. Displaced persons in the past three years (2013-2016) have strained the nation's water/wastewater/transportation infrastructure

Table 2.2. Descriptive statistics of statistically significant parameters in the six models

Independent Parameter	Min/Max	Average
Geographic parameters		
Rhineland Palatinate (1 if being resident of Rhinal Palatinate, otherwise 0)	0/1	0.04
Bavaria (1 if being resident of Bavaria, otherwise 0)	0/1	0.17
Brandenburg (1 if being resident of Brandenburg, otherwise 0)	0/1	0.03
Baden Württemberg (1 if being resident of Baden Württemberg)	0/1	0.11
Berlin (1 if being resident of Berlin)	0/1	0.08
Hamburg (1 if being resident of Hamburg)	0/1	0.03
Individual parameters		
Gender (1 if male, otherwise 0)	0/1	0.54
Marital status (1 if single, otherwise 0)	0/1	0.33
Number of years lived in city (years)	0/99	27.28
Student (1 if being student, otherwise 0)	0/1	0.05
Retired (1 if being retired, otherwise 0)	0/1	0.21
Have you lived at least 5 years in the current city (1 if true, otherwise 0)	0/1	0.86
Born where currently living (1 if true, otherwise 0)	0/1	0.33
Highest level of education (1 if some high school, otherwise 0)	0/1	0.46
Highest level of education (1 if high school diploma, otherwise 0)	0/1	0.18
Individual income (1 if income is less than €34,999, otherwise 0)	0/1	0.68
Grew up in middle city (1 if true, otherwise 0)	0/1	0.26
Grew up in rural area (1 if true, otherwise 0)	0/1	0.57
Employed for wage or salary (1 if true, otherwise 0)	0/1	0.50
Responsible for water utility bill (1 if true, otherwise 0)	0/1	0.85
Radio is the primary source of news (1 if true, otherwise 0)	0/1	0.07
Internet is the primary source of news (1 if true, otherwise 0)	0/1	0.41
Household parameters		
Number of people living in the household is 2 or less (1 if true, otherwise 0)	0/1	0.69
Household income (1 if household income is less than €34,999, otherwise 0)	0/1	0.49
Household income (1 if household income is €75,000 or above, otherwise 0)	0/1	0.18
Household owned by someone in household with mortgage or loan (1 if true, otherwise 0)	0/1	0.21
No children (1 if No children under the age of 5 living in the household. Otherwise 0)	0/1	0.94

Table 2.3. Respondents who perceive and who do not perceive an impact on the performance of the water, wastewater, and transportation infrastructure systems due to displaced persons

	City scale	National scale	Both the City and National scales
Respondents do not perceive an impact on any individual system (W, WW, and T)	79.24%	68.21%	78.15%
Respondents perceive an impact on all system (W, WW, and T)	20.76%	31.79%	21.85%

Note: W- Water, WW- Wastewater, T-Transportation

Table 2.4. Percentage of responses that perceive an impact on a system/scale due to the arrival of displaced persons

Perceived an impact on the system at the specified scale	Water system, city	Wastewater system, city	Transportation system, city	Water system, nation	Wastewater system, nation	Transportation system, nation
Water system, city	23.10%	22.50%	18.20%	21.20%	21.80%	19.40%
Wastewater system, city	22.50%	24.90%	19.10%	22.50%	23.40%	21.50%
Transportation system, city	18.20%	19.10%	27.40%	19.40%	19.40%	26.80%
Water system, nation	21.20%	22.50%	19.40%	32.00%	29.80%	27.10%
Wastewater system, nation	21.80%	23.40%	19.40%	29.80%	32.00%	26.80%
Transportation system, nation	19.40%	21.50%	26.80%	27.10%	26.80%	36.60%

2.4.2. Nonparametric Tests

The results from the nonparametric tests reflect the removal of the I-do-not-know responses from the six questions. The remaining responses for each question were coded as follows: strongly disagree - 1, disagree - 2, agree - 3, and strongly agree - 4 (n = 325). The Kruskal-Wallis tests were used to assess the null hypothesis that public perceptions of displaced persons impacting the three infrastructure systems were statistically equivalent at each scale. For both tests, the results indicated that the null hypothesis could be accepted and the three infrastructure systems (water, wastewater, and transportation) were perceived as the same, with corresponding p-values of 0.767 and 0.873 at the national and city scales, respectively. In other words, there was no statistical difference in the public perceptions of the three infrastructure systems within each scale, for either city or nation.

The Mann-Whitney test was used to evaluate the null hypothesis that there was no statistical difference in the perceived impacts toward each systems water/wastewater/transportation between the city and the national scale. The corresponding p-values were 0.019 for the water system, 0.0275 for the wastewater system, and 0.0224 for the transportation system. Thus, the results indicate that the perceived impact of displaced persons on each infrastructure system is statistically different when the same infrastructure type is compared at the city and the national scale.

2.4.3. Statistical Modeling

The results for the best-fit binary probit models are shown in Tables 2.5-2.7. Due to space limitations, we do not discuss each of the 57 statistically significant parameters in this manuscript (see Table 2.5-2.7). Instead, we have selected a set of recurrent parameters among the water, wastewater, and transportation infrastructure systems, at the city and national scales (see Table 2.8). We use this set to discuss how hosting communities perceive the impacts of displaced persons on these infrastructure systems.

Table 2.5. Model results regarding whether incoming displaced persons in the past three years (2013-2016) impacted the respondents' water system service at city and national scales

Independent Variable Unless otherwise indicated, variables are 1 if true, otherwise 0	**City Scale** Parameter (t-stat)	St.Dev. (t-stat)	Marginal Effects	**National Scale** Parameter (t-stat)	St.Dev. (t-stat)	Marginal Effects
Constant	-2.260 (-4.470)	*fixed*		-0.705 (-1.550)	*fixed*	
Residing in Rhineland-Palatinate	1.274 (2.860)	*fixed*	0.002	-	-	-
Residing in Bavaria	-	-	-	4.662 (4.980)	*fixed*	0.006
Residing in Brandenburg	-	-	-	3.073 (2.690)	*fixed*	0.004
Residing in Baden-Württemberg	-	-	-	2.499 (3.020)	8.544 (4.860)	0.003
Gender (Male)	-0.490 (-1.800)	*fixed*	-0.0009	-	-	-
Employed for wage or salary	0.861 (2.650)	*fixed*	0.001	-	-	-
Being a student	-	-	-	-8.091 (-4.270)	*fixed*	-0.010
Being Retired from workforce	-	-	-	-2.101 (-3.400)	*fixed*	-0.002
Primary source of news the Internet	0.996 (3.800)	*fixed*	0.001	-	-	-
Primary source of news the radio	-	-	-	-3.781 (-3.520)	*fixed*	-0.004
Highest level of education is some high school	-2.268 (-3.620)	6.597 (5.630)	-0.004	1.205 (2.880)	*fixed*	0.001
Grew up in middle city	-	-	-	1.601 (3.540)	*fixed*	0.002
Have you lived at least 5 years in the current city	0.725 (1.800)	*fixed*	0.001	-	-	-
Individual income less than €34,999	-1.936 (-3.920)	3.404 (5.880)	-0.003	-	-	-
Number of people living in the household is 2 or less	-	-	-	-3.016 (-4.540)	*fixed*	-0.003
No children under the age of 5 living in household	-	-	-	-1.742 (-2.930)	7.203 (5.780)	-0.002
Log likelihood at convergence	*-178.909*			*-198.319*		
AIC	*377.800*			*422.600*		
Number of observations	*352*			*346*		

Table 2.6. Model results regarding whether incoming displaced persons in the past three years (2013-2016) impacted the respondents' wastewater system service at city and national scales

Independent Variable Unless otherwise indicated, variables are 1 if true, otherwise 0	**City Scale**			**National Scale**		
	Parameter (t-stat)	St.Dev. (t-stat)	Marginal Effects	Parameter (t-stat)	St.Dev. (t-stat)	Marginal Effects
Constant	-0.774 (-3.070)	*fixed*		1.272 (2.500)	*fixed*	
Residing in Baden-Württemberg	1.227 (3.230)	*fixed*	0.086	-	-	-
Residing in Rhineland-Palatinate	1.670 (3.530)	*fixed*	0.118	-	-	-
Residing in Bavaria	-	-	-	1.517 (4.360)	*fixed*	0.126
Residing in Berlin	-	-	-	-1.198 (-2.160)	*fixed*	-0.099
Primary source of news the radio	-	-	-	-3.973 (-3.500)	*fixed*	-0.331
Gender (Male)	-	-	-	-0.664 (-2.590)	*fixed*	-0.055
Born where currently living	0.634 (2.470)	*fixed*	0.044	-	-	-
Being a student	-4.716 (-3.350)	*fixed*	-0.333	-6.974 (-3.970)	*fixed*	-0.581
Highest level of education is High school diploma	-	-	-	-1.476 (-3.740)	*fixed*	-0.123
Household Income is less than €34,999	0.730 (2.970)	*fixed*	0.051	-0.515 (-1.430)	6.393 (6.400)	-0.043
Number of people living in the household is 2 or less	-0.967 (-3.740)	*fixed*	-0.068	-1.073 (-3.760)	*fixed*	-0.089
Household owned by someone in household with mortgage or loan	-0.731 (-2.220)	*fixed*	-0.051	-	-	-
Primary source of news is the Internet	-0.769 (-2.140)	4.376 (6.11)	-0.054	-	-	-
Highest level of education is some high school	-1.127 (-3.200)	2.851 (6.31)	-0.079	-	-	-
No children under the age of 5 living in household	-	-	-	-1.200 (-2.470)	1.300 (6.820)	-0.100
Marital status (single)	-	-	-	0.485 (1.540)	1.923 (5.130)	0.040
Log likelihood at convergence	*-178.884*			*-192.165*		
AIC	*381.800*			*412.3*		
Number of observations	*348*			*343*		

Table 2.7. Model results regarding whether incoming displaced persons in the past three years (2013-2016) impacted the respondents' transportation system service at city and national scales

Independent Variable Unless otherwise indicated, variables are 1 if true, otherwise 0	**City Scale**			**National Scale**		
	Parameter (t-stat)	St.Dev. (t-stat)	Marginal Effects	Parameter (t-stat)	St.Dev. (t-stat)	Marginal Effects
Constant	-0.008 (-0.020)	*fixed*		2.805 (2.390)	*fixed*	
Residing in Rhineland-Palatinate	4.677 (4.320)	*fixed*	0.003	1.416 (2.560)	*fixed*	0.407
Residing in Bavaria	-	-	-	1.392 (4.110)	*fixed*	0.401
Residing in Baden-Württemberg	3.256 (4.400)	2.373 (3.710)	0.002	1.159 (3.170)	*fixed*	0.333
Residing in Brandenburg	-	-	-	1.227 (2.130)	*fixed*	0.353
Residing in Hamburg	-	-	-	-2.071 (-2.320)	*fixed*	-0.596
Gender (Male)	-0.734 (-2.140)	*fixed*	-0.0005	-	-	-
Grew up in rural area	-2.745 (-4.130)	*fixed*	-0.001	-0.731 (-2.390)	*fixed*	-0.21
Born where currently living	2.069 (4.210)	*fixed*	0.001	0.881 (3.520)	*fixed*	0.253
Primary source of news is the internet	-	-	-	0.543 (2.420)	*fixed*	0.156
Primary source of new is the radio	-3.356 (-3.260)	*fixed*	-0.002	-	-	-
Citizenship (German)	-	-	-	-2.454 (-2.190)	*fixed*	-0.706
Household income is between €35,000 - €74,999	0.946 (2.650)	*fixed*	0.0006	-	-	-
Household Income is at least €75,000	-	-	-	-0.920 (-2.890)	*fixed*	-0.265
If number of people living in the household is 2 or less	-	-	-	-0.828 (-3.110)	*fixed*	-0.238
No children under the age of 5 living in household	-4.199 (-5.500)	6.190 (6.280)	-0.002	-1.136 (-2.740)	2.394 (9.150)	-0.327
Being a student	-	-	-	-3.530 (-3.270)	2.857 (2.750)	-1.016
Log likelihood at convergence	*-205.393*			*-218.954*		
AIC	*432.800*			*469.9*		
Number of observations	*368*			*360*		

Table 2.8. Recurrent parameters influencing public perceptions

Across Scales	
Infrastructure systems	***Discussion points***
Water, Wastewater, and Transportation systems at the city scale	• No statistical difference in the perceived impact of displaced persons on the three infrastructure systems at the city scale • Statistical difference in the perceived impact on each infrastructure system
Water, Wastewater, and Transportation systems at the national scale	• No statistical difference in the perceived impact of displaced persons on the three infrastructure systems at the national scale • Statistical difference in the perceived impact on each infrastructure system
Influence of the city and national scale	• Results indicate the relevance of the geographic scale selected to assess public perceptions of the impact on infrastructure systems
City Scale	
Independent variable Unless otherwise indicated, variables are 1 if true, otherwise 0	***Discussion points***
Residing in Rhineland-Palatinate Residing in Baden-Württemberg	• Influence of the quantity of incoming displaced persons on the public perceptions of hosting communities. • Potential influence of the secondary migration patterns from surrounding states influencing public perceptions from residents • Opposition sentiments among residents
Born where currently living Resided in current city for at least 5 years	• Influence of the longevity of end users in the system on the public perceptions of hosting communities • Place attachment theory
Primary source of news the radio Primary source of news the Internet	• Primary source of the news reflects the influence of news source on public perceptions

Table 2.8. Continued

National Scale

Independent variable Unless otherwise indicated, variables are 1 if true, otherwise 0	***Discussion points***
Residing in Baden-Württemberg Residing in Bavaria	• Quantity of incoming displaced persons influence public perceptions of hosting communities • Opposition sentiments among residents
Residing in Berlin Residing in Hamburg	• Community supported initiatives to receive and integrate displaced persons influence public perceptions of hosting communities
Household income No children under the age of 5 living in the household	• Modeled as random parameter on the three infrastructure systems, and as such, indicates a considerable heterogeneity among respondents
Being a student	• Potential influence of generational and educational level in attitudes toward incoming displaced persons

2.5. Discussion

2.5.1. Perceptions of Infrastructure Systems across Scales

The nonparametric tests revealed that, within the city and national scales, no statistical difference was present in the perceived impact of displaced persons on the three infrastructure systems. Between the two scales, however, a statistical difference was revealed in the perceived impact on each infrastructure system. That is to say, at the city scale people perceived the impact of displaced persons on the water/wastewater/transportation system differently to people considering the impact at the national scale. These findings are consistent with previous work from Kingston et al. (2000). These results indicate the relevance of the geographic scale selected when assessing public perceptions of the impact on infrastructure systems.

These results may mean that individuals view the performance of the infrastructure as a system-of-systems within the same geographic scale, as opposed to individually assessing the performance of each system. In other words, the systems are perceived to be functioning as an integrated part of the built environment, inseparable from other infrastructure types. If one system is impacted negatively, such as the transportation system being inundated, the results suggest that users assume other systems are also negatively impacted. This appears to be the case in spite of the underground water and wastewater systems being out-of-sight, out-of-mind. These results may be linked to place-attachment theory. This theory holds that in a place where the sense of community is higher than that of the individual, residents will eventually view negatively any disruptor to that place (Devine-wright 2009). Hosting communities may perceive as a disruptor to their community the impact by displaced persons to any of the water, wastewater, and transportation systems. This would be true regardless their framing that community at the local or national scale. This tendency among people underscores the importance of interdependencies among these three infrastructure systems (Rinaldi et al. 2001). Disruptions to one infrastructure system may influence perceptions of the other infrastructure systems.

In contrast, a difference was found within geographic scales (and between) when it came to the socio-demographic and geographic drivers influencing the perceived impact of displaced persons on each system. Parameters influencing the likelihood of (not) perceiving an impact differed for each infrastructure system. In the instances where a parameter was revealed to influence multiple systems or scales, the marginal impact varied for each system or scale (see Tables 2.5-2.7). From a practical and theoretical point of view, this demonstrates, importantly, that while aggregate perceptions may not differ across units of analysis, the underlying drivers influencing those perceptions do in fact differ. For example, while the water, wastewater, and transportation systems were in aggregate perceived consistently within a geographic scale, each system's relative contribution to that aggregate differed. Practically speaking, this means that before a targeted solution can be introduced to provide such services engineers must discover which infrastructure system is driving the perception of impact. Theoretically speaking, this attests to the heterogeneity of perceptions and respective drivers that may, taken in the aggregate, appear homogenous.

2.5.2. City Scale

Considering the influences of the geographic parameters at the city scale (see Tables 2.5-2.7), if one was a resident of either of Rhineland-Palatinate or Baden-Wurttemberg, one was more likely to perceive that displaced persons impacted at least two (of the three) systems (see Tables 2.5-2.7). Residents of Rhineland-Palatinate were more likely to perceive that displaced persons impacted the water, wastewater, and transportation systems within their city. In 2015, Rhineland-Palatinate received only 4.83% of all incoming displaced persons in Germany, while its neighboring states Baden-Wurttemberg, Hesse, and North Rhine-Westphalia received 12.97%, 7.23%, and 21.24% of displaced persons, respectively (see Table 2.1; Katz and Garrelts 2016). In sum, this region received in 2015 more than 41% of Germany's total incoming displaced persons. It may seem surprising that a state with a low percentage of incoming displaced persons perceived the impact more strongly than a state with a higher percentage. We suggest that these results may be capturing opposition sentiments among the typically politically conservative residents of the state of Rhineland-Palatinate. For instance, it has been reported that the refugee crisis enabled anti-immigration political parties to gain more popular support (The Guardian 2016), potentially from among residents who feared the country could not handle so many refugees (The Guardian 2015; The New York Times 2015). In 2016, for example, Rhineland Palatinate voted into parliament a populist right-wing party that supported anti-immigration policies (DW 2016). Another possible explanation for this observed trend in the data relates to the secondary migration patterns toward Rhineland-Palatinate from surrounding states. More than 41% of incoming displaced persons arrived in states around Rhineland-Palatinate, and as these individuals were not required to stay in their initially assigned locations, it is reasonable to think there may have been secondary migration patterns in this area. This could have increased the number of displaced persons allocated in the state of Rhineland-Palatinate and therewith the stress placed on the infrastructure services in this region. Unfortunately, no data exists, to the best of our knowledge, on secondary migration trends that could validate this explanation.

Previous studies have suggested that anti-immigrant attitudes are based on residents feeling their privileges are threatened by immigrants and are also influenced by the country's economic situation and the proportion of immigrants to the existing population (Quillian 1995; Semyonov et al. 2006). Residents of Baden-Wurttemberg were more likely to perceive displaced persons as impacting the transportation and the wastewater systems. For the transportation system, we modeled being a Baden-Wurttemberg resident as a random parameter. We found that 91.50% of residents were more likely to perceive displaced persons as impacting the transportation system (see Table 7). Receiving 12.97% of Germany's displaced persons Baden-Wurttemberg was the third highest recipient (Katz and Garrelts 2016). These results, again, may be reflecting the influence of the quantity of displaced persons arriving to specific geographic locations in shaping public perceptions from hosting communities. Respondents were more likely to perceive that displaced persons had impacted the water system at the city scale if they met on of three conditions: they were employed for a wage or salary, had lived at least five years in the current city, or had used the internet as a primary source of news. Respondents that were born where they are currently living had an increased likelihood of perceiving that displaced persons had impacted the wastewater and transportation systems at the city scale. This possibly captures the influence of their longevity using the infrastructure system. Residents that were born where they are currently living and have lived at least five years in the city develop a stronger place attachment sentiment toward their community and are likely to be more familiar with the infrastructure systems (Brown and Perkins, 1992). These stronger sentiments can make residents more protective of their environment and community following an event that they perceive modifies the status quo.

Respondents with an individual income below €34,999 or with the highest level of education as high school had a decreased likelihood of perceiving that displaced persons had impacted the water system and were found to be random parameters (see Table 2.5). Approximately 37% of respondents having a maximum of a high school education had an increased likelihood of perceiving displaced persons as having impacted the water system, while 63% of them had a decreased likelihood. The random parameter individual income below €34,999 showed that 28.50% of respondents had an increased likelihood of perceiving that displaced persons had impacted the water system while 71.50% had a decreased likelihood. Respondents whose highest level of education was high school and whose primary source of news was the Internet had a decreased likelihood of perceiving displaced persons as having impacted the wastewater systems; they were modeled as random parameters (see Table 2.6). Among high school-educated respondents, 34.60% had an increased likelihood of perceiving displaced persons as having impacted the wastewater system, while 65.40% of them had a decreased likelihood. Respondents that used the internet as their primary source of news was a random parameter that indicated that 43.00% had an increased likelihood of perceiving that displaced persons had impacted the wastewater system, while 57.00% had a decreased likelihood. The parameter for source of news may capture the versatility of various media and their command of a wider variety of information. Furthermore, the influence of the source of the news is consistent with previous findings from Kosho (2016). Kosho (2016) found that the media has a strong influence on public attitudes in the context of migration, and how information is presented to hosting communities influences public opinions and policies regarding migration issues. In this study, the method of receiving news is a proxy for “how.” Various news sources selected by respondents may represent the flexibility of the news received. For instance, the internet provides a user flexibility in selecting news stories and providers (This is shown in the data, where getting news from the internet shows both negative and positive impacts on different models). In contrast, the radio provides minimal selection on the story delivered (also shown in the data, where getting the news from the radio does not show this variability in directionality). Nonetheless, no clear trend was found that linked the primary source of news with residents being more or less likely to perceive the impacts of displaced persons.

Concerning household characteristics, respondents with no children under the age of five living in the household had a decreased likelihood of perceiving that displaced persons had impacted the transportation city; this was modeled as a random parameter. As such, 75.12% of respondents had a decreased likelihood of perceiving that displaced persons had impacted the transportation system, and 24.88% had an increased likelihood.

2.5.3. NATIONAL SCALE

In general, the statistically significant geographic parameters made people more likely to perceive displaced persons as having impacted the infrastructure systems. In Bavaria, for instance, residents were more likely to perceive impacts on the water, wastewater, and transportation systems (See Tables 2.5-2.7). Notably, however, residents of the state of Berlin and Hamburg were less likely to perceive impacts on the wastewater and transportation system, respectively. According to Katz and Garrelts (2016), the states of Hamburg and Berlin demonstrated a particular ability to innovate when it came to receiving and integrating displaced persons. Hamburg innovated by unifying the delivery of services such as shelter and food to displaced persons, joining services with the implementation of cross-disciplinary agencies.

With the goal of minimizing local opposition, residents were invited to participate in the process of situating displaced persons, of initiating changes to building regulation and zoning ordinances to effectively allocate centers for displaced persons (Katz and Garrelts 2016). Berlin adopted modular housing to create villages in communities, and to identify locations to install long-term housing for displaced persons (Katz and Garrelts 2016). These unique circumstances presented in these two states may have influenced residents' attitudes toward incoming displaced persons. Moreover, our results provide some evidence of cases showing that involving hosting communities during the allocation and provision of services to displaced persons can positively influence public attitudes.

Interestingly, Bavaria residents were found to be statistically significant in all three models at the national scale. They were more likely to perceive displaced persons impacting the water, wastewater, and transportation systems (see Tables 2.5-2.7). These results may be influenced by Bavaria receiving in 2015 the second highest percentage (15.33%) of displaced persons in Germany (Katz and Garrelts 2016), and by opposition sentiments among the residents of Bavaria and the support of local authorities to minimize the quantity of incoming displaced persons being allocated on Bavaria (BBC 2016; DW 2017). Similarly, to results concerning systems at the city scale in Baden-Wurttemberg, these results may be evidence that the magnitude of displaced persons allocated to a particular state influences public perceptions. Regarding demographic parameters, respondents identifying as students were statistically significant across all three systems at the national scale, decreasing, on average, the likelihood of perceiving impacts from displaced persons (see Tables 2.5-2.7). These results may be capturing the influence of generational and educational levels, consistent with previous studies that have suggested younger or educated individuals have more positive attitudes about immigration (Hainmueller and Hiscox 2007; Foster 2008; Berg 2010). Interestingly, the citizenship of respondents—whether German citizen or not—was only statistically significant parameter in one out of the six models (See Table 7). These results may reflect a lack of existing bias regarding whether being a citizen from the country hosting displaced persons is an issue while perceiving the impacts on infrastructure systems.

In the context of respondents' household characteristics, all significant parameters had a decreased likelihood of perceiving displaced persons having impacted the infrastructure systems (i.e., number of people living in the household, household income, and having no children under the age of five living in the household). In particular, 53.20% of households with an income below €34,999 were less likely to perceive displaced persons as having impacted the wastewater system. The parameter of residents having no children under the age of five living in the household was modeled as a random parameter in all three models at the national scale. It was found that for the three different systems 59.60% of respondents were less likely to perceive displaced persons as having impacted the water system. In addition, 82.20% of respondents were less likely to perceive displaced persons as having impacted the wastewater system. Furthermore, 68.20% of respondents were less likely to perceive displaced persons as having impacted the transportation system. The presence of multiple random parameters indicates a considerable heterogeneity among respondents.

It is important that engineers and decision makers know about these geographic and socio-demographic parameters driving public perceptions of hosting communities. With such knowledge, they could identify specific geographies where infrastructure projects may experience public protest, and where public outreach and participation in projects is particularly needed. At a higher level of decision-making, ministries and municipalities may be benefited from identifying sources of public support or opposition during the distribution process of displaced persons. Cities and regions with more positive perceptions of incoming displaced persons may facilitate the provision of infrastructure services as well as the integration process of displaced persons into hosting communities. In addition, identifying geographies where public outreach has been particularly effective allows the replication of successful infrastructure policy. For instance, the described community-supported initiatives from Berlin and Hamburg attest to the benefits of public involvement in infrastructure projects intended to support the provision of services to displaced persons.

In summary, recent conflicts, natural and human-made, have drastically increased the global number of displaced persons. This means that engineers and policy makers around the globe must consider how the resulting population dynamics impact critical infrastructure systems and their users. Of course, infrastructure policy and design must take into account more than just communities' perceptions. Key aspects of any project plan, for example, include cost, regulatory standards, schedules, quality, and safety. Nevertheless, and as shown here, if we improve our understanding of the public perceptions of infrastructure systems, we may be able to better provide critical infrastructure services to incoming displaced persons and hosting communities alike.

2.6. Conclusions

This study addresses a gap in the literature regarding public perceptions of the impact, at both city and national scales, of extreme population dynamics on water, wastewater, and transportation systems. This research contributes to the knowledge regarding infrastructure systems that host a disaster-displaced population, but that are geographically distinct from a primary disaster event.

One contribution of this study is that it identifies the influence of the geographic scale on public perceptions of the hosting communities, as revealed by the nonparametric tests. Within the city or national scale, public perceptions of the impact of displaced persons on the water, wastewater, and transportation systems were not statistically different. What were statistically different in contrast, were perceptions of the impact on each infrastructure system between geographic scales. This difference in public perceptions across the city and national scales may be due to respondents perceiving the impacts from displaced persons on one system of systems at the city scale, and as another, distinct system of systems at the national scale.

The second contribution of this study is that the demographic parameters influencing public perceptions were different for the three infrastructure systems at both city and national scales. Nonetheless, there were certain parameters that were significant in more than one model (e.g., the longevity of respondents with the systems, having no children under the age of five living in the household, the primary source of news, and the highest level of education; Tables 2.5-2.7). These parameters suggest that end users with more experience with the infrastructure systems from their community are more likely to perceive the impacts or disruptions on the systems in their community (Devine-Wright 2009). These results may have been shaped by place attachment (Devine-Wright 2009). Place attachment theory states that residents from a hosting community will develop negative sentiments toward disruptions to their community. This interpretation is supported by the nonparametric test results, which indicated the absence of statistical difference in perceptions of the impact of displaced persons on water, wastewater, and transportation systems within the same geographic scale.

The results also emphasize that, when dealing with planning and construction, local authorities (e.g., municipalities), engineers, and policy makers must consider the influence of different geographic scales on public perceptions. The identification of the heterogeneous drivers of public support can lead to community-supported infrastructure solutions to provide services to displaced persons. It is important for engineers and policymakers to understand the public perceptions of the ways that population displacement impacts infrastructure, as well as the corresponding heterogeneous drivers of those perceptions. Such an understanding allows them to implement end user-supported solutions, minimize project protest, and ensure high levels of infrastructure service.

Future research should explore hosting community perceptions with alternative data-collection methods, such as interviews with residents. These methods may capture the reasons behind the statistical trends observed here, thereby enriching the results of the present study. Additionally, we recommend a study that assesses the impact of displaced persons on the housing sector. Indeed, this aspect of the built environment has been extensively discussed in the media as a source of stress for hosting communities (e.g., BBC 2016; DW 2017; Reuters 2018). We also recommend exploring geographic contexts other than those included in this study to assess possible cultural similarities and differences amongst hosting communities and the displaced population. It would be interesting, for instance, to study attitudes and perceptions of hosting communities in Turkey, which is a developing country and has, during the past four years, hosted more displaced persons than any other country in the world (UNHCR 2018). Finally, and from a practical perspective, future research should consider how existing project-delivery systems (e.g., public-private-partnerships or integrated project delivery) can leverage public perceptions during the different stages of infrastructure projects such as planning, design, and construction.

CHAPTER 3. UNDERSTANDING HOSTING COMMUNITIES AS A STAKEHOLDER IN THE PROVISION OF WATER AND WASTEWATER SERVICES TO DISPLACED PERSONS

This chapter has been reproduced with minor changes from:

Araya. F, Faust. K, Kaminsky. J. Understanding hosting communities as a stakeholder in the provision of water and wastewater services to displaced persons. *Journal of Sustainable Cities and Society* Volume 57, June 2020, 102114. https://doi.org/10.1016/j.scs.2020.102114

Contributions: Felipe Araya performed investigation, data analysis, writing of the original draft, validation and visualization. He also performed, with the help of the two co-authors, the conceptualization of the study, methodology development, review and editing of the manuscript.

Abstract: In 2015, when German hosting communities had to accommodate more than 1.2 million displaced persons, they encountered multiple challenges with their built environment. The provision of infrastructure services to incoming displaced people may require changes to the existing infrastructure. As such, the provision of infrastructure services may elicit either support or opposition within hosting communities regarding the methods used to provide infrastructure services to displaced persons. This study assesses how hosting communities perceive various methods of providing water and wastewater infrastructure services to displaced persons; these methods are making (1) no changes, (2) temporary changes, or (3) permanent changes to the preexisting infrastructure. Statistical modeling and qualitative analysis were coupled to analyze data gathered from a survey deployed in 2016 to local German residents. The results suggest that the magnitude of displaced persons received by hosting communities, understood as a contextual factor, influenced hosting communities' perceptions toward different categories of infrastructure alternatives. Qualitative analyses revealed that hosting communities do consider alternatives beyond physical changes, such as educating displaced people on using existing infrastructure. By

understanding hosting communities' perceptions of the provision of services to displaced people, decisionmakers and utility engineers may develop sustainable infrastructure alternatives with input from hosting communities.

Keywords: displaced persons, water infrastructure, wastewater infrastructure, stakeholders, hosting communities' perceptions

3.1. Introduction

In recent years the world has seen an increase in the number of persons displaced (UNHCR 2016a; UNHCR 2017; UNHCR 2018). In 2017, the number reached a record 68.5 million (UNHCR 2018). Of those displaced, approximately 28 million were either refugees or asylum seekers—the highest numbers seen since the end of the World War II (UNHCR 2018). Within this context, this study focuses on the influx to Germany of displaced people, many of whom were fleeing the instability of the Middle East. Germany received the largest number of new asylum applications in Europe, receiving 2.4 million new asylum applications in 2015 and 2016 combined (Eurostat 2016; Eurostat 2017). With this high magnitude of incoming persons, Germany presented a unique opportunity to explore the impacts of a rapid and sudden influx of displaced persons on existing urban infrastructure systems that are geographically independent from the natural or human-made disaster. Notably, hosting displaced persons from Middle East is by no means a unique problem for Europe; indeed, it is a global issue (Dabaieh and Alwall, 2018). For instance, due to a political crisis in Venezuela, approximately 3.3 million people migrated, between 2015 and 2018, to surrounding countries in Latin America and the Caribbean region (UNHCR 2019).

The accommodation of displaced persons within hosting communities has evolved from primarily rural accommodation—e.g., refugee camps—to accommodations within urban centers;

as of 2017, a majority of displaced people worldwide were living in urban environments (Brandt 2019; UNHCR 2016b; UNHCR 2018; World Bank 2017). Consequently, the provision of infrastructure services to displaced persons no longer occurs in isolation from local, hosting communities, but in conjunction with the existing built environment. As such, the existing urban infrastructure in hosting communities is used to serve the displaced population, posing challenges for continuity of service with in-place utilities in some instances. An example of this was as the capacity of pre-existing facilities (e.g., initial reception centers) in German hosting communities was exceeded during the 2015/2016 displacement, emergency accommodations were arranged to temporally accommodate displaced persons (e.g., sport halls, former schools; Faure et al., 2020). The status of these emergency accommodations in Germany was far from standardized, and as such, multiple alternatives to provide infrastructure services were used. Namely, in the case of the water and wastewater services, alternatives such as new connections, temporary sanitary facilities, or portable toilets were implemented at these emergency accommodations (Hacker et al., 2019).

Given this context, the provision of infrastructure services may impact the functionality of the existing systems serving the hosting community—e.g., increase water demands affecting fire flows water pressure (Varis et al., 2006; Faust and Kaminsky 2017). Moreover, to provide such services, utilities must consider how to convey them to displaced populations—e.g., use the pre-existing piped water supply or truck in water via temporary infrastructure. Having the hosting community share its services with a displaced one—rather than offering separate services provided, say, on the outskirts of cities in rurally located “refugee camps”—changes the interactions of local communities with displaced persons. Now, in the urban environment, the provision of services to displaced persons is interdependent with the provision of services with the hosting community. A reduction in the level of service for displaced persons is a reduction in the level of service for the community. As such, a hosting community may have its perceptions altered on *how* services are provided to displaced persons.

For a hosting community to house a displaced population, the community's stakeholders could be directly impacted on a day-to-day basis. To thus mitigate any potential negative sentiment and continue providing aid in such a migratory disaster context, it is essential that decision-makers understand and consider the perceptions of the hosting community as a stakeholder. In fact, to achieve sustainable infrastructure projects, research has found it is critical for decision-makers to determine the expectations and perceptions of the local public (Faust et al., 2016). Specifically, they need to understand the public's concerns and to respond to them in a timely manner (Valdes-Vasquez and Klotz 2012). Acknowledging and understanding communities as a valid stakeholder related to the development of infrastructure projects can minimize the risks of overlooking communities' interests, which can impact project performance (Araya et al., 2018; Valentin et al., 2018). However, limited studies exist doing so in the context of disaster recovery taking place in a community that is geographically distinct from the location of the disaster—understanding the provision of urban infrastructure services to a large influx of displaced persons as a migratory disaster. As such, this study contributes to the literature of disaster stakeholder management by revealing and understanding how communities that host a large influx of displaced persons perceived different methods to provide water and wastewater infrastructure services to displaced populations. Consequently, this better understanding can be leveraged during the planning and decision-making process of infrastructure alternatives to implement community-supported alternatives. In practicality, including hosting communities during early stages of projects can help project implementation run smoothly; namely, in the form of minimizing potential public opposition from hosting communities toward infrastructure alternatives.

Researchers have left largely unexplored the analytical category of population dynamics—i.e., shifting populations whether in regards to total population or the types of users on the system. But in fact, population dynamics drives a good deal of system-wide demand at any given moment, potentially posing a challenge to civil infrastructure systems (Kaminsky and Faust 2018; Faust and Kaminsky 2018; Faust and Abraham 2014; Faust et al. 2017). In the case of steady population growth or chronic urban decline, the time-frame—years if not decades—allows infrastructure managers and authorities to plan for and adapt existing infrastructure footprints (Faust and Kaminsky 2017). Mass migrations to hosting communities—typically does not allow for this frontend planning and end up testing the capabilities of existing systems. For instance, in the case of Germany, by exceeding the capacity of pre-existing accommodation facilities. With this context in mind, this study seeks to explore the following research question: How do hosting communities perceive various methods of providing water and wastewater infrastructure services to displaced persons? The various methods in question are namely making (1) no changes, (2) temporary changes, or (3) permanent changes to the local, preexisting infrastructure systems. Quantitative and qualitative analyses are coupled to analyze data gathered from a survey deployed to local German residents to respond to the research questions.

3.2. Background

Previous work has primarily focused on post-disaster housing accommodations and infrastructure service provision at the geographic point of impact in countries with developing economies (e.g., El-Anwar and Chen 2012; Hosseini et al., 2016; Johnson et al., 2006). The literature has established that a critical role in successful disaster recovery is that of planning and coordination (Arneson et al., 2017; El-Anwar and Aziz 2014; Hwang et al., 2016; Opdyke et al., 2017; Venable et al., 2018).

However, the consequences of natural disasters often affect not just the region in which the disaster occurred (i.e., the point of impact); for instance, the provision of services to those displaced by the disaster often occurs outside the geographic location of the disaster, whether natural or human-made. Notably, limited studies exist that have addressed challenges due to such secondary/cascading impacts on infrastructure systems outside of the point of disaster (Faust and Kaminsky 2017; Hacker et al., 2019; Faure et al., 2019).

Faust and Kaminsky (2017) found that to provide water and wastewater infrastructure services—the systems of interest for this study—in hosting communities, organizers may encounter the following challenges: insufficient technical capacity; operational and maintenance issues of the systems; availability of resources; lack of front end planning; and the coordination, design, and construction of new infrastructure, among other challenges (Faust and Kaminsky 2017). Notably, Faust and Kaminsky (2017) found that for water-sector utility professionals to address such challenges, it was foundational for them to have information ahead of time regarding where incoming populations may be geographically accommodated across the city—i.e., planning. Similarly, the studies from Faure et al. (2019) and Hacker et al. (2019) assessed how utilities responded, at the organizational level, to the provision of water and wastewater services to displaced persons in urban settings. Hacker et al. (2019) found that water and wastewater utility employees showed confidence in being able to respond to the technical demands posed by the accommodation process. Also, designing alternatives (e.g., water and wastewater connections) called for improvisation, as standardized procedures were not available. The authors also found a general need to improve communication and the allocation of responsibilities among multiple stakeholders. Faure and colleagues (2019) found that the organizational response to the accommodation of displaced people was reactive instead of proactive. A fundamental aspect of a proactive response is, interestingly, the inclusion of the cultural background of displaced people when planning the design of accommodations. Moreover, the education of displaced persons was commonly referred to as an alternative to minimize cultural differences with hosting communities' practices (Faure et al., 2019).

The general methods in which hosting communities can provide water and wastewater services may be classified as temporary or permanent. Permanent water infrastructure alternatives might include the installation of new distribution pipelines and rehabilitation of distribution systems (Sakata 2015; Vivar et al., 2016). Temporary alternatives may include the use of water storage tanks (Bloom 2015) or water trucks (UNHCR 2013). Permanent alternatives for wastewater services could include septic tanks (Cabrera Pacheco et al., 2010), or expanding the capacity of—or building a new—water treatment plant (Cabrera Pacheco et al., 2010; UNHCR 2016b). Temporary alternatives could include portable chemical toilets (Brown et al., 2012). These temporary alternatives are typically quicker to implement and are not intended to persist beyond the disaster response and recovery period. However, these temporary alternatives may not always be financially or environmentally sustainable (Randall et al., 2008; UNHCR

2016b). Permanent alternatives, on the other hand, take longer to implement and can, during critical early stages, delay the provision of water and wastewater services (Brown et al., 2012). Nonetheless, these initial delays may bring long-term benefits such as higher certainty and better-quality services (Randall et al., 2008).

As noted above, the allocation of refugees in host countries has shifted from rural to urban areas, where infrastructure already exists. This was often not the case, historically, for selected locations of refugee camps (Al-Husseini, 2011; Potter et al., 2009; Vivar et al., 2017). Thus, an area of study that remains largely unexplored is hosting communities' reactions to alternatives to providing water and wastewater services to displaced persons in urban settings.

Researchers have extensively studied the importance of accounting for a project's stakeholders' interests during decision-making processes (e.g., Doloi 2012; Eschenbach and Eschenbach 1996; Herazo and Lizarralde 2016; Mitchell et al., 1997; Olander 2007; Yu and Leung 2018). Stakeholder opposition can directly influence project outcomes such as overruns in time, cost, and poor quality (Nguyen et al., 2009; Olander and Landin 2005; Yang and Shen 2014). Similarly, when local communities oppose a project, researchers have repeatedly found they impact the performance of projects, such as roads, nuclear plants, energy infrastructure, and water infrastructure (Bertsch et al., 2017; Hurlimann and Dolnicar 2010; Valentin et al., 2018; Wang et al., 2016). It is generally agreed that ignoring public opposition has detrimental consequences on infrastructure projects (Gerasidi et al., 2009; Hurlimann and Dolnicar 2010; Jiang et al., 2015). Consequently, if project managers are to achieve the expected project's outcomes, they must be able to identify the necessary stakeholders involved throughout project phases and manage these stakeholders' interests (Olander and Landin 2005). Notably, Olander and Landin (2005) found that stakeholders are primarily influenced by how project managers present benefits and costs associated with the project (Olander and Landin 2008). Thus, if organizers understood a benchmark for how hosting communities view different methods of providing services, they could use it to model communications to the public so as to shift support toward the desired outcomes.

This study seeks to address two limitations in the existing literature. First, researchers have yet to explore, in the context of hosting communities situated outside the region directly impacted, the incorporating of stakeholders other than experts during the planning and decision-making process for infrastructure alternatives. Second, the literature has focused on developing countries despite approximately 20% of displaced persons being hosted in developed countries.

3.3. Methods

To leverage insights from the survey data, the research team used quantitative and qualitative approaches. The statistical modeling reveals drivers of public perceptions, while the qualitative analysis provides insight into preferred methods by the hosting communities for the provision of services. The mixed-method research design allowed us to compensate for each method's weakness (Neuman 2011). Coupling quantitative approaches with qualitative analysis increases the robustness of the research findings by providing a multi-dimensional assessment of the subject achieved through synergy (Fellows and Liu 2015).

3.3.1. Survey Deployment

In August 2016, during the peak influx of displaced peoples into the European Union (Eurostat 2016; Katz et al., 2016), a survey was deployed to the general public in Germany. The survey aimed to assess attitudes toward and perceptions of the incoming displaced persons, their impacts on infrastructure systems, and alternatives to provide infrastructure services. Of particular interest to this study are the following seven questions:

Questions 1 and 2: *The physical **water (wastewater)** infrastructure should be permanently expanded to accommodate increased users, specifically refugees and asylum seekers, on the system. (Strongly Disagree/Disagree/Agree/Strongly Agree/ I do not know)*

Questions 3 and 4: ***Water (wastewater)** service should be provided to incoming asylum seekers and refugees using temporary infrastructure. (Strongly Disagree/Disagree/Agree/Strongly Agree/ I do not know)*

Questions 5 and 6: *No permanent changes should be made to our **water (wastewater)** infrastructure system to provide service for the incoming asylum seekers and refugees. (Strongly Disagree/Disagree/Agree/Strongly Agree/ I do not know)*

Question 7: *As asylum seekers and refugees have arrived in Germany, people and organizations have attempted to provide them with **WATER** and **WASTEWATER** services. Please pretend you were in charge of this, and write a paragraph to describe **HOW** you think this ideally should, or should not, be accomplished? (Open-ended question)*

Before deployment, the survey underwent content validation by eight subject-matter experts whose expertise covered survey analysis, public perceptions modeling, and the water infrastructure sector. Additionally, to verify word choice, data correctness, and assess survey accessibility for the general public, the survey was pre-deployed to 15 individuals—excluded from the final pool of valid responses—with limited knowledge on water infrastructure systems. The survey underwent Institutional Review Board reviews at the University of Texas at Austin and the University of Washington. The survey was conducted in German and deployed by a third party, Qualtrics LLC, a web-based survey company (Qualtrics 2016). The survey took on average 21 minutes to complete, thus avoiding survey fatigue (Hess et al., 2012). A random sampling based on geographic quotas was used to be representative of Germany. The final sample consisted of 416 valid responses—spanning residents from 16 states in Germany from Questions 1-6, and 221 open-ended responses from Question 7.

As can be observed in Table 3.1 the valid responses collected with the survey align with the population distribution of the German states in 2016 (Destatis 2018).

Table 3.1. Distribution of German population and survey responses

State	Percentage of German population (2016)	Percentage of responses from the Survey (2016)
Bavaria	15.7%	16.1%
Baden-Württemberg	13.3%	10.3%
Berlin	4.3%	7.9%
Brandenburg	3.0%	3.4%
Bremen	0.8%	1.2%
Hamburg	2.2%	2.6%
Hesse	7.5%	11.5%
Lower Saxony	9.6%	7.7%
Mecklenburg-Western Pomerania	2.0%	2.4%
North Rhine-Westphalia	21.7%	21.6%
Rhineland-Palatinate	4.9%	3.8%
Saarland	1.2%	1.7%
Saxony	4.9%	2.9%
Saxony-Anhalt	2.7%	2.6%
Schleswig-Holstein	3.5%	2.4%
Thuringia	2.6%	1.7%

3.3.2. Statistical Modeling using Binary Probit Models

Questions 1-6 are each individually modeled using binary probit models with random parameters to identify parameters that influence perceptions of three types of alternatives to providing water and wastewater services to incoming displaced persons. The three alternative types are to make no changes to the systems, to make temporary changes, and to make permanent changes. To provide an option to respondents unknowledge about the question, the survey included an I-do-not-know option. A neutral option was not included so as to avoid inducing decision paralysis (Barge and Gehlbach 2012; Krosnick 1991). Responses to the questions were collapsed to a binary variable—support/oppose. Support included responses marked as strongly agree and agree, while oppose included responses marked as strongly disagree and disagree. Given the evidence in the literature that responses indicating a lack of opinion do not enhance the quality of data collected (Krosnkick 1999; Krosnick et al., 2002), the responses marked as *I do not know*, were excluded from the modeling process.

Geographic (i.e., state of residence) and socio-demographic characteristics (e.g., age, the highest level of education) were modeled as independent parameters (see Table 3.2). The impact of local culture or factors may be revealed by including geographic characteristics.

Table 3.2 shows the descriptive statistics of the independent parameters revealed in the statistical models. Note that the mean can be interpreted as the percentage of respondents in that category; for instance, a mean of 0.42 for "Grew up in the city currently residing in" indicates that 42% of respondent grew up in the city they are currently residing in.

Table 3.2. Selected descriptive statistics

Parameters (unless otherwise indicated variables are 1 if true, otherwise 0)	**Mean**
Geographic parameters	
Residing in the state of Baden-Württemberg	0.11
Residing in the state of Bavaria	0.16
Residing in the state of North Rhine-Westphalia	0.21
Residing in the state of Rhineland-Palatinate	0.04
Residing in the state of Saxony	0.03
Individual parameters	
Grew up in the city currently residing in	0.42
Area grew up in is classified as rural (less than 5,000 inhabitants)	0.18
Area grew up is classified as middle city (between 20,000 to 100,000 inhabitants)	0.27
Highest level of education is high school diploma	0.17
Highest level of education is college degree	0.22
Employment status is employed for wage or salary	0.50
Employment status is out of work and looking for work	0.02
Employment status is unable to work	0.07
Responsible for water utility bill	0.85
Internet is the primary source of the news	0.41
Frequency of following the news is at least once per week	0.10
Individual annual income is between €20,000 and €34,999	0.28
Individual annual income is between €35,000 and €74,999	0.27
Individual annual income is below €34,999	0.66
Lived at least three years in current city	0.91
Household parameters	
One or two persons living in the household	0.69
No cars in the household	0.14
One or two cars in the household	0.81
Annual household income is between €35,000 and €74,999	0.35
Household owned by respondent or someone in the household	0.21

A binary probit model was used, as it indicates the likelihood that a dependent parameter takes one of the two possible outcomes depending on the observable independent parameters (Washington et al., 2011); namely, the level of support/oppose toward each of the three infrastructure alternatives to provide water and wastewater services to displaced persons for this study.

$$P_{support} = \beta_{support,n} \cdot X_{support,n} + \varepsilon_{support,n} \quad \text{(Eqn 1)}$$

where $\beta_{support,n}$ is a vector of estimated parameters for the outcome support, $X_{support,n}$ is a vector of observable/independent characteristics for the outcome support for a given observation n (e.g., state of residence, highest education level), and $\varepsilon_{support,n}$ represents a vector containing the error term (Washington et al., 2011). Estimated parameters may be either fixed or random; random parameters capture a heterogeneous impact on the outcome across the population (Mannering et al., 2016; Washington et al., 2011). Random parameters are introduced by a density function (see Equation 2), $f(\beta/\varphi)$, where φ is a vector of parameters of the corresponding specified density function (Washington et al., 2011). All random parameters were normally distributed (Washington et al., 2011).

$$\mathrm{P}_{\mathrm{support}}^{\mathrm{rp}}(\mathrm{n}) = \int P_{support}(n) f(\beta/\varphi) d\beta \qquad \text{(Eqn 2)}$$

The Akaike Information Criterion (AIC) was used to determine the best-fit model (Bozdogan 1987; Vrieze 2012). Conversely, to assess the impact of each independent parameter on the dependent variable, average marginal effects were calculated across the sample for a unitary change in the independent parameter (Washington et al., 2011). A negative marginal effect indicates a decrease in the likelihood that the respondent supports a specific infrastructure alternative to provide water/wastewater services to displaced persons; a positive marginal effect indicates an increased likelihood of support.

3.3.3. Qualitative Analysis

The qualitative analysis provides insight into how the hosting public perceives displaced persons ought to be provided water and wastewater services. Researchers classified as valid those responses that referred to alternatives to providing water and wastewater services to displaced persons. The final sample consists of 221 valid responses. All valid responses were iteratively and objectively coded into different categories and subcategories to develop a coding dictionary, thus providing a basis for replicability and validity (Krippendorff 2004).

Table 3.3 summarizes the codes used. A response from one respondent can, notably, be coded in more than one category/subcategory. As such, unique responses refer to the number of individuals responding to a specific category/subcategory, whereas total responses refer to the total phrases coded to that specific category/subcategory. The coding dictionary was validated through inter-coder reliability checks (Saldaña 2013), resulting in an interrater percentage of agreement of 93% and thus, ensuring the consistency of the results (McHugh 2012).

Table 3.3. Topical codes for how water and wastewater services should be provided to incoming displaced persons

	Codes	Quotation Examples
Statements related to making no changes to the infrastructure systems	Instruct displaced persons about how to use existing services	"Education of the refugees about the correct usage of the water and sewage systems to avoid complications with water and sewage processes"
	Adequate capacity exists or minor maintenance required	"In Germany, the water and wastewater supply is very good, nothing needs to be changed."
	Providing services to displaced persons is not a challenge	"I don't know what the problem should be, [we have the capacity]."
	Use existing facilities	"One should only provide the apartments when a wastewater and water supply is available."
Statements related to the use of temporary infrastructure	Use temporary alternatives	"…. provisionary supplies, in the form of temporary toilets, water tapping points, etc."
Statements related to making permanent changes to the infrastructure	Building new infrastructure elements	"Wherever it is necessary, new lines need to be laid."
	Financial investment	"They would have to build new pipelines in a cost-effective way"

Table 3.3. Continued

Statements related to the opposition of the provision of services	Opposition	"No refugee collections. There are already enough German needs that are not being helped."
Statements related to the support of providing services but not specific to a method	Avoid transferring the cost to citizens	"The state would have to cover all cost with already paid taxes, without any additional costs for the citizens"
	Involve stakeholders in the development of alternatives	"Very difficult. There is no ideal solution. It stands and falls with the understanding of the people who live in the immediate surroundings."
	Services are a basic human right	"All people are equal and therefore have the same basic right to water."

3.3.4. LIMITATIONS

As with any study, this study is not without its limitations. One comes from the use of a cross-sectional survey as the data-collection method to study public perceptions. Perceptions are dynamic by nature and may change with the public receiving new information, interacting with other individuals and groups, or being subject to new events. However, the use of a survey allows researchers to collect a large amount of data and draw results from a statistically significant sample from the population being studied. Another limitation is that the use of a survey limits direct interaction with respondents. However, by answering open-ended questions regarding the subject under study, respondents may be able to communicate a more elaborate opinion (Singer and Couper 2017). A third limitation is that this study focuses on Germany; as such, social and cultural factors may influence perceptions from respondents. Nonetheless, the accommodation of forcibly displaced people and the corresponding provision of essential infrastructure services is a global problem (UNHCR 2018), and limited studies have been conducted in nations with developed economies. Important to note, the mixed-method framework implemented in this study may be replicated in other countries hosting displaced persons. Finally, this study focuses only on water and wastewater infrastructure systems. Therefore, the findings of this study may not be directly transferable to other infrastructure systems such as transportation or energy.

3.4. Results

Within hosting communities, citizens offer higher levels of support to alternatives for providing water and wastewater services that involve some sort of change to the existing systems—either temporary or permanent—than to those that make no changes (Figures 3.1 and 3.2).

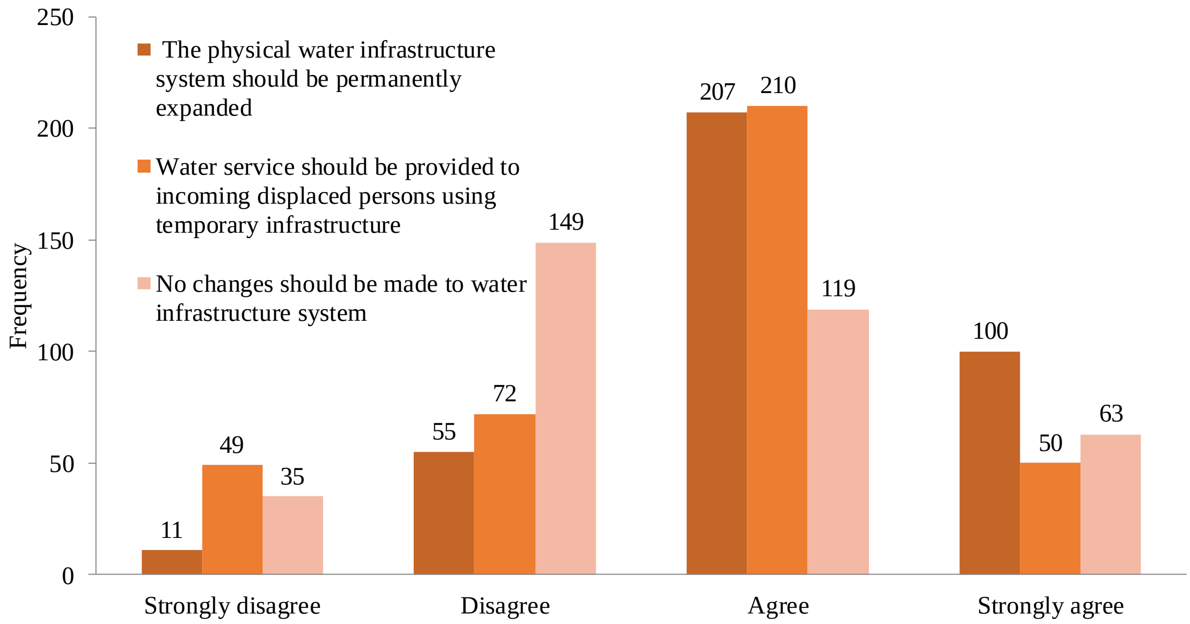

Figure 3.1. Alternatives to provide water services to incoming displaced persons

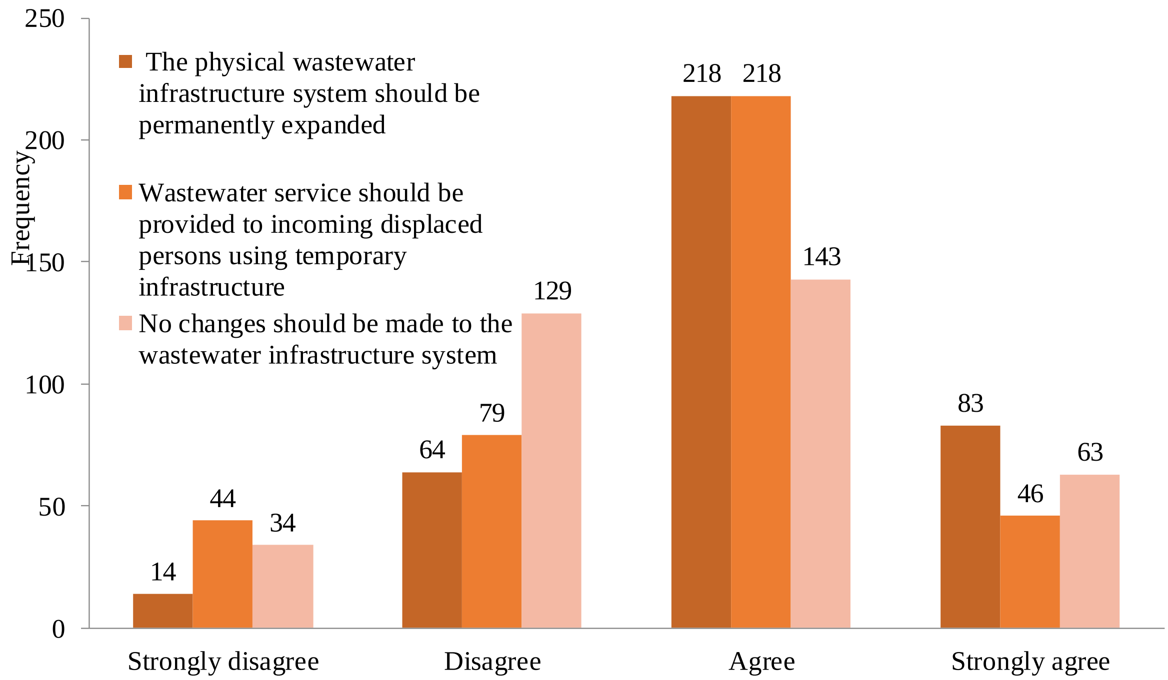

Figure 3.2. Alternatives for providing wastewater services to incoming displaced persons

The results of the six best-fit binary probit models are shown in Tables 3.4-3.6. The presence of multiple random parameters suggests considerable heterogeneity across the population. Due to space limitations, we include in the discussion section below primarily parameters that were recurrent among multiple models.

Table 3.4. Model results regarding making no permanent changes to the existing systems for the provision of water/wastewater services to displaced persons (---- indicates the parameters was not statistically significant in respective model; "fixed" indicates that this variable is a fixed parameter)

Parameter (Unless otherwise indicated, variables are 1 if true, otherwise 0)	**Water Infrastructure**			**Wastewater Infrastructure**		
	Parameter (t-statistic)	Standard deviation (t-statistic)	Marginal Effects	Parameter (t-statistic)	Standard deviation (t-statistic)	Marginal Effects
Constant	-0.143 (-0.710)	Fixed		1.404 (3.540)	Fixed	
Geographic parameters						
Residing in the state of Rhineland Palatinate	1.419 (2.110)	Fixed	0.479	----	----	----
Residing in the state of North Rhine-Westphalia	-5.141 (-3.940)	8.048 (5.130)	-1.738	----	----	----
Individual parameters						
Grew up in the city currently residing in	-0.666 (-2.640)	Fixed	-0.225	----	----	----
Area grew up in is classified as middle city (between 20,000 to 100,000 inhabitants)	----	----	----	0.413 (2.140)	Fixed	0.155
Lived at least three years in current city	----	----	----	-0.778 (-2.160)	Fixed	-0.292
Employment status is unable to work	4.127 (3.420)	Fixed	1.395	----	----	----
Employment status is unemployed and looking for work	----	----	----	3.851 (2.540)	Fixed	1.443
Highest completed level of education is college degree	----	----	----	-0.362 (-1.720)	Fixed	-0.136
Primary source of news is the Internet	0.585 (2.320)	Fixed	0.198	0.146 (0.600)	4.537 (5.420)	0.055
Individual annual income is below €34,999	----	----	----	-0.779 (-4.250)	Fixed	-0.292
Household parameters						
One or two persons living in your household	0.584 (1.970)	24.722 (4.620)	0.197	----	----	----
Log likelihood at convergence		-242.267			-238.5	
AIC		502.5			493.0	
Number of observations		366			369	

Table 3.5 Model results regarding making temporary changes to the existing systems for the provision of water/wastewater services to displaced persons (---- indicates the parameters was not statistically significant in respective model; "fixed" indicates that this variable is a fixed parameter)

Parameter (Unless otherwise indicated, variables are 1 if true, otherwise 0)	**Water Infrastructure**			**Wastewater Infrastructure**		
	Parameter (t-statistic)	Standard deviation (t-statistic)	Marginal Effects	Parameter (t-statistic)	Standard deviation (t-statistic)	Marginal Effects
Constant	1.912 (6.110)	Fixed		2.302 (4.280)	Fixed	
Geographic parameters						
Residing in the state of Baden-Württemberg	-1.304 (-4.370)	Fixed	-0.202	-0.770 (-2.540)	Fixed	-0.021
Residing in the state of Rhineland Palatinate	-1.585 (-2.680)	Fixed	-0.246	----	----	----
Residing in the state of Saxony	-1.068 (-2.100)	Fixed	-0.166	-1.137 (-2.570)	Fixed	-0.031
Residing in the state of North Rhine-Westphalia	0.152 (0.420)	2.660 (4.860)	0.023	6.762 (3.03)	23.427 (3.600)	0.186
Individual parameters						
Individual annual income is between €20,000 and €34,999	-0.495 (-2.260)	Fixed	-0.076	----	----	----
Employment status is employed by wage or salary	-0.391 (-1.820)	Fixed	-0.061	----	----	----
Grew up in the city currently residing	----	----	----	0.353 (1.680)	Fixed	0.010
Are you responsible for your water utility bill	-0.525 (-1.720)	Fixed	-0.081	-1.715 (-3.28)	Fixed	-0.047
Primary source of news is the Internet	1.077 (2.780)	5.299 (5.920)	0.167	-0.104 (-0.420)	2.634 (5.960)	-0.003
Household parameters						
Annual household income is between €35,000 and €74,999	----	----	----	0.407 (1.950)	Fixed	0.011
No cars in the household	-0.056 (-0.100)	8.487 (4.830)	-0.008	-0.625 (-1.460)	4.219 (4.370)	-0.017
Log likelihood at convergence		-217.651			-222.4	
AIC		461.300			468.8	
Number of observations		381			387	

Table 3.6. Model results regarding making permanent changes to the existing system for the provision of water/wastewater services to displaced persons (---- indicates the parameters was not statistically significant in respective model; "fixed" indicates that this variable is a fixed parameter)

Parameter (Unless otherwise indicated, variables are 1 if true, otherwise 0)	**Water Infrastructure**			**Wastewater Infrastructure**		
	Parameter (t-statistic)	Standard deviation (t-statistic)	Marginal Effects	Parameter (t-statistic)	Standard deviation (t-statistic)	Marginal Effects
Constant	1.455 (3.930)	Fixed		0.107 (0.270)	Fixed	
Geographic parameters						
Residing in the state of Bavaria	----	----	----	1.336 (2.300)	Fixed	0.027
Individual parameters						
Primary source of news is the Internet	-0.431 (-1.930)	Fixed	-0.018	1.932 (3.230)	5.602 (5.330)	0.039
Area grew up in is classified as rural (less than 5,000 inhabitants)	----	----	----	-0.977 (-3.600)	Fixed	-0.019
Area grew up in is classified as middle city (between 20,000 to 100,000 inhabitants)	-0.595 (-2.480)	Fixed	-0.025	----	----	----
Frequency of following the news is at least once a week	1.910 (2.280)	Fixed	0.081	----	----	----
Individual annual income is between €35,000 and €74,999	0.514 (1.850)	Fixed	0.022	----	----	----
Are you responsible for your water utility bill	-0.699 (-1.930)	Fixed	-0.029	----	----	----
Grew up in the city currently residing	1.686 (3.070)	3.987 (5.320)	0.071	----	----	----
Lived at least three years in current city	----	----	----	0.647 (1.720)	Fixed	0.013
Highest completed level of education is high school diploma	0.797 (1.950)	0.850 (2.320)	0.034	----	----	----
Household parameters						
One or two cars in the household	0.535 (2.080)	Fixed	0.023	0.767 (2.970)	Fixed	0.015
Annual household income is between €35,000 and €74,999	----	----	----	-0.737 (-3.260)	Fixed	-0.015
Household owned by respondent or someone in the household	----	----	----	2.638 (3.660)	2.196 (3.990)	0.053

Table 3.6. Continued

Log likelihood at convergence	-157.533	-169.6
AIC	337.1	359.3
Number of observations	373	379

The qualitative analysis resulted in five primary categories (see Table 3.7). Three of the five categories were aligned with the alternatives assessed using the statistical modeling—making no changes, making temporary changes, and making permanent changes. Interestingly, two categories emerged— (1) opposition and (2) support from respondents regarding the general provision of services.

Table 3.7. Alternatives for providing water and wastewater infrastructure services to displaced persons

Categories	Total (Unique)	Responses Percentage
Making no permanent changes to the water or wastewater infrastructure	**138 (128)**	**53%**
Instruct/educate displaced persons on how to use the existing services as they are	18	7%
The existing system has adequate capacity and/or may require minor maintenance	29	11%
Displaced persons do not pose a challenge for our systems in terms of provision of services	55	21%
Accommodate displaced persons in existing buildings already connected to services	36	14%
Using temporary water or wastewater infrastructure	**13 (13)**	**5%**
Using temporary alternatives (e.g., water trucks)	13	5%
Making permanent changes to water or wastewater infrastructure	**29 (28)**	**11%**
Building new infrastructure elements (e.g., pipes)	14	5%
Make financial investments to expand capacity	15	6%
Opposition to the provision of water or wastewater service	**22 (22)**	**9%**
Support for providing water or wastewater service not specific to a method	**57 (55)**	**22%**
Authorities should provide services using alternatives that do not transfer the cost to citizens	11	4%
Involve stakeholders (e.g., experts, politicians, communities) and discuss openly about alternatives	33	13%
Services are a basic human right that must be provided permanently	13	5%
Total	**259 (221)**	**100%**

3.5. Discussion

The statistical modeling results of this study revealed that the perceptions of hosting communities were influenced by multiple geographic and socio-demographic parameters. Regarding the hosting community's thoughts on how water and wastewater services should be provided, we gain insights through the qualitative analysis.

The significance of geographic parameters suggests that community members' perceptions of the different methods were influenced by such contextual conditions as the state of the preexisting infrastructure systems, local policies impacting perceptions, or the number of displaced people accommodated. For instance, in North Rhine-Westphalia—a state that in 2016 received ~27% of Germany's displaced population (AIDA, 2017)— residents were less likely to support making no changes to their preexisting water system and more likely to support temporary changes to both their water and wastewater systems when providing this service to the additional population. In Rhineland Palatinate, a state that received in 2016 ~5% Germany's displaced population in 2016 (AIDA, 2017), residents were more likely to support making no changes to the water system (see Table 3.4). These same residents from Rhineland Palatinate were less likely to support temporary changes to their system (see Table 3.5). It could be expected that receiving over a quarter of those displaced arrivals would be considerably more noticeable in a community than one receiving a small percentage. Illustrating this, Saxony residents (who received ~3% of the displaced population; AIDA, 2017) were less likely to support making temporary changes to provide both water and wastewater infrastructure services. Perhaps these residents perceived no need for change. The dichotomy between the magnitude of displaced persons a community received and the respective views toward different categories of infrastructure alternatives is apparent throughout. Bavaria, which accommodated the fourth largest fraction of displaced people in Germany in 2016 (AIDA, 2017), was more likely to support making permanent changes to the wastewater infrastructure system (see 3.Table 6).

It is important to note that a majority of the geographic parameters were modeled as fixed parameters, highlighting the localized and uniform regional impact across the population. This result, consistent with other studies, reinforces the notion that context can shape perceptions of the built environment (Faust and Kaminsky 2018; Yang and Faust 2019). Notably, the influence of context was found in the open-ended responses; for instance "*In our area, there is far and wide no applicants settling there, so there is no effort to change anything,*" or "*maybe, in the affected areas, invest in better supply.*" Similarly, the influence of the context was captured on how infrastructure systems would respond to the provision of services to displaced people, as 21% of respondents did not see the arrival of displaced persons being a challenge for their pre-existing infrastructure systems (see Table 3.7). For example, "*In Germany, this should not play a big role. Our drinking water is of really good quality and plenty of fresh water is available*." And, "*In Germany, the water and wastewater supply is very good, nothing needs to be changed.*"

In more practical terms, the results of the geographic parameters seem to align with the distribution system that German authorities established as public policy. Our results are consistent with previous studies that found an intrinsic relationship between public policies and public perceptions (Hays 1996; Burstein 2003) and between rapid urbanization and public perceptions from hosting communities (Islam et al., 2014). These results may be used by decision-makers and utilities to identify infrastructure alternatives that are more likely to be locally supported (or opposed). More importantly, this can identify potential local opposition—seemingly driven by not perceiving a need for the particular alternative—that could be mitigated through campaigns or communication with the communities. Knowing this, decision-makers are better equipped to respond to such concerns in a timely manner. For example, authorities and utility engineers from the state of North Rhine-Westphalia may try to meet the new demands by using temporary—as opposed to permanent alternatives.

Further, decision-makers know that this region perceived a need for infrastructure changes to be made as this region was more likely to oppose making no changes to the preexisting water infrastructure system to meet the additional demands. This finding emphasizes the need for locally tailored policies and infrastructure alternatives regarding the accommodation and provision of services for incoming displaced populations. From a practical standpoint, however, although locally tailored policies are suggested, it is notable that general patterns can predict which category of alternatives will be successful in select regions—e.g., using temporary versus permanent.

Concerning the impact of socio-demographic parameters on the hosting community perceptions, we discuss here recurrent parameters. Found to be statistically significant in all the six models was the parameter of using the Internet as the primary news source (see Tables 3.4-3.6). Clearly, these results emphasize the influence of the communication of information (e.g., the news) on perceptions from hosting communities. These results are consistent with findings from Kosho (2016), who emphasized the relevance of the news source in shaping perceptions. The marginal effect of using the Internet as the primary source of the news differed notably, among the models (Table 3.4-3.6). Residents using the Internet as the primary source of the news were more likely to support making no or temporary changes to provide water services, and less likely to support making permanent changes to provide water services (See Tables 3.4-3.6).

Interestingly, however, when it came to wastewater services, residents were more likely to support making no or permanent changes and less likely to support making temporary changes to provide wastewater services. The authors posit that this may be due to temporary wastewater alternatives, such as temporary toilets (Breitenbach 2016), being viewed as unhygienic or a public health issue (Devitt et al., 2016; Firedler et al., 2006).

A key factor regarding how the public reacts to new projects is communication (Wang et al., 2016). We must look, then, at the influence of communication on perceptions of hosting communities. That is, what was the media coverage of the response by local authorities in charge of managing the accommodation of displaced persons. German chancellor Angela Merkel declared multiple times during the early stages of the arrival of displaced persons that Germany could handle the challenges of providing asylum to the incoming displaced persons. She projected, in other words, a "we can-do this" attitude (Cohen 2015). Local authorities and infrastructure managers should pay careful attention to how residents interact with information on providing infrastructure services to displaced persons. In the case of water and wastewater services, utilities could develop campaigns to inform and make the public aware that existing infrastructure systems in their communities may require to be adapted or modified to provide services to displaced persons. They should also communicate that, regardless the number of displaced persons, actions may have to be taken to maintain a preexisting quality of services. For example, if residents are unaware of potential changes in urban infrastructure (e.g., shut off the water supply service to install new pipes to expand the network), they may react negatively to alternatives to provide services or against the incoming displaced persons may emerge across hosting communities, due to the inconvenience of the changes that need to be done to the systems.

The parameters capturing residents who have lived at least three years in the city or have grown up in the city they are currently living in were found significant in four out of the six models (see Tables 3.4 and 3.6). These respondents were less likely to support providing water and wastewater services by making no changes and more likely to support making permanent changes (see Tables 3.4 and 3.6). The significance of these parameters may be capturing the experience and longevity of residents' interaction with the local infrastructure systems. This interpretation is consistent with previous studies that found drivers of public perceptions of infrastructure systems include experience and longevity with their local infrastructure systems (Araya et al., 2019; Dean et al., 2016). Additionally, it has been found that more experienced residents are more likely to perceive disruptions on infrastructure systems from their local environment due to the emotional tie between residents and their community (Clarke et al., 2018; Devine-Wright 2009). In other words, residents with more experience with their local infrastructure systems become more aware of the challenges faced by their local infrastructure systems.

Not only residents who have lived at least three years in the city and having grown up in the city they are currently living in were found to influence the preferred alternatives to provide water and wastewater services, but respondents also refer to the alternative of including multiple stakeholders involved in the provision of infrastructure services. The qualitative analysis revealed the perceived importance of involving multiple stakeholders, including the public, in decision-making (see Table 3.7). Thirteen percent of respondents mentioned that stakeholders, such as politicians, experts, the utilities, and local communities, should be involved in deciding how to provide infrastructure services to displaced persons. One resident remarked, "*Experts, who can offer and provide assistance, should be consulted for advice.*" Another said, "*Very difficult. There is no ideal solution. It stands and falls with the understanding of the people who live in the immediate surroundings*." Notably, these responses are aligned with the perspective from researchers who have claimed the necessity of taking a participatory approach in the management of infrastructure alternatives in disaster contexts (Araya et al., 2019; Crawford et al., 2013; Faust and Kaminsky 2018; Hacker et al., 2019; Pearce 2003; Venable et al., 2018). In reality, local authorities and utility engineers may leverage higher stakeholder engagement if they acknowledge the influence of the length of time residents have resided and interacted with the existing infrastructure systems on their communities and encourage the involvement of multiple stakeholders. For example, in the case of hosting communities, public participation through public consultation or focus groups may begin with the more experienced residents from hosting communities—as they have more experience with the system and are more aware of potential disruptions—and then expand to less experienced residents.

Finally, complementing the physical alternatives, the findings reveal managerial alternatives that fall into the "make no changes" category (see Table 3.7). Seven percent of respondents expressed that incoming displaced persons should be educated and trained on how to use the existing services as they are. For example, respondents indicated that *"education of the refugees and asylum seekers about the correct usage of the water and sewage systems to avoid complications with water and sewage processes."* These results also emphasize that some respondents recognized that cultural differences might exist between the incoming population and hosting communities. Moreover, such cultural differences translate into different ways to use water and wastewater services, such as toilets, as discussed in the news (Breitenbach 2016; Breitenbach 2015). Similarly, a study from Faure and colleagues (2019) found that stakeholders involved in the provision of water and sanitation services to displaced persons also preferred educating displaced persons, as education is understood to be part of a long-term integration process of displaced persons in the hosting community culture.

3.6. Conclusions

Coupling statistical modeling and qualitative analysis, this study assessed the public perceptions of hosting communities toward infrastructure alternatives used to provide water and wastewater services to displaced persons. The findings of this study contribute to the existing literature of disaster stakeholder management by better understanding hosting communities as a valid stakeholder involved in the provision of urban infrastructure services, as well as by providing a framework to facilitate the incorporation of hosting communities in the management of stakeholders involved in the provision of infrastructure services to displaced people. In this way, the study helps promote the sustainable planning and development of urban hosting communities regarding the provision of infrastructure services to displaced persons.

The results suggest that the magnitude of displaced persons received by hosting communities influenced hosting communities' perceptions of different categories of infrastructure alternatives. Residents from states receiving high percentages of displaced people were more likely to support alternatives involving some sort of change (i.e., temporary or permanent), while residents from states receiving low percentages of displaced people were more likely to support alternatives making no changes to existing systems. The majority of statistically significant geographic parameters were modeled as fixed parameters, highlighting how location uniformly influences the perceptions of hosting communities. Furthermore, socio-demographic parameters captured how residents' perceptions of infrastructure alternatives were influenced by the primary source of the news as well as residents' longevity of residence and experience interacting with the infrastructure systems. These results reinforced the notion that context influences how hosting communities perceive alternatives of providing infrastructure services to displaced people.

Coupling the quantitative analysis with qualitative analysis allowed for a better understanding of how the water and wastewater infrastructure services should be provided to displaced persons. As such, physical alternatives of providing infrastructure services were complemented by respondents offering managerial alternatives, such as training to incoming displaced persons to use existing services or requiring the involvement of multiple stakeholders to provide infrastructure services to incoming displaced persons (e.g., utilities, experts, and hosting communities).

From a practical standpoint, our results emphasize that local authorities, infrastructure managers, and utility engineers should consider hosting communities as a valid stakeholder during the implementation of urban infrastructure alternatives. More specifically, recommendations are made that account for contextual conditions specific to hosting communities (e.g., the magnitude of incoming displaced people accommodated in the community) when decision-makers decide how to accommodate displaced persons and provide them water and wastewater services without losing public support from hosting communities.

It is recommended to investigate other contexts to compare and contrast the influence of contextual conditions on perceptions of hosting communities; researchers should, for instance, study nations with developing economies, which may have less complex infrastructure systems. A first step towards considering hosting communities as a valid stakeholder is to capture and benchmark hosting community perceptions of how services are rendered to displaced communities. Next, these views should be incorporated into the decision-making process of tailoring alternatives and policies of providing infrastructure services to displaced persons.

CHAPTER 4. A FRAMEWORK TO PROVIDE URBAN INFRASTRUCTURE TO DISPLACED PERSONS ACCOUNTING FOR LOCAL AUTHORITIES AND HOSTING COMMUNITIES

Abstract: In 2016, Germany received approximately 50% of the 1.2 million asylum applications in the European Union. The applicants represented a population influx of displaced people that were accommodated primarily in urban settings, creating challenges for engineers and managers who need to meet the new services' demands of those displaced without disrupting services to the preexisting residents. To achieve this, local authorities and engineers must consider temporary or permanent alterations to the existing infrastructure—changes that may provoke opposition from a hosting community depending on their perception of the changes. This study proposes a modeling framework that allows decision-makers to account for hosting communities' perceptions of alternatives to provide infrastructure to displaced persons. The framework uses an agent-based model that is enabled by publicly available information, a survey deployed to German communities in 2016, and 10 interviews with stakeholders involved in the accommodation of displaced persons in Germany. Our results indicate that alternatives used by local authorities did not align with community-supported alternatives. To minimize such misalignments, we recommend that local authorities, early on in developing infrastructure alternatives, take into account the perceptions of hosting communities. Ultimately, the proposed framework promotes the sustainable provision of urban infrastructure to displaced persons.

Keywords: displaced persons; urban infrastructure; Agent-based modeling.

4.1. Introduction

All over the world in recent years, there has been an increase in the number of displaced people (UNHCR, 2017; UNHCR, 2018; UNHCR, 2019). In 2018, human-made conflicts displaced more than 70 million (UNHCR, 2019). Massive population displacement can create multiple challenges regarding accommodating displaced persons. Coming up with accommodation can impact the built environment of hosting communities (Kirbyshire et al., 2017; UNHCR, 2009). Of interest to this study is the case of Germany, to which approximately 1.2 million displaced persons, due to Middle East instability, applied for asylum (Eurostat, 2016; Eurostat, 2017). Those displaced persons in Germany were primarily accommodated in urban settings, in contrast to the rural settings (refugee camps) that have historically been used (Brandt, 2019; Katz et al., 2016; UNHCR, 2006).

Bearing much of the burden of accommodating displaced persons falls on engineers and managers in charge of infrastructure services. They must quickly create capacity—both temporary and permanent—to provide sufficient services while also giving consideration to how doing so may disrupt services to those already residing in hosting communities (Faust and Kaminsky, 2017). Decision-makers and engineers must respond to incoming displaced persons' emergency needs for basic services, such as access to drinking water as well as wastewater services. At the same time, utility engineers need to ensure that the residents of hosting communities are not negatively impacted. Ultimately, an influx of displaced persons may require changes to infrastructure systems (e.g., temporary/permanent system expansion) that disrupt services to hosting communities. For example, in the context of water infrastructure, making changes to existing water networks may require construction activities that interrupt the continuity and disrupt the provision of water services to residents of hosting communities.

When additional populations disrupt existing urban infrastructure services, such disruption may influence how residents from hosting communities perceive different alternatives used by authorities to provide infrastructure services, namely supporting/opposing infrastructure alternatives (Araya et al., 2018; Araya et al., 2020a). The literature has captured the consequences of public opposition to infrastructure projects performance such as increased budgets and delayed schedules (Friedler et al., 2006; Jiang et al., 2016; Valentin et al., 2018). These consequences underscore the importance, during the decision-making process, of local authorities incorporating hosting communities as stakeholders.

Recently, researchers have explored how providing urban infrastructure services to incoming displaced persons may impact different stakeholders such as utility managers (Faure et al., 2019; Faure et al., 2020; Hacker et al., 2019) and hosting communities (Araya et al., 2019; Araya et al., 2020a; Kaminsky and Faust, 2017). However, existing studies have focused on single stakeholders, leaving a gap in our understanding of how multiple stakeholders may interact—how well they align—during the decision-making process.

In the context of decision-making processes about providing water and wastewater services to displaced persons, this study proposes and demonstrates a modeling framework to identify misalignments between hosting communities and local authorities. The framework is enabled by data from three sources—publicly available information, interviews with stakeholders, and a survey deployed to German hosting communities. The proposed framework may assist decision-makers and engineers to identify misalignments with local communities regarding the provision of infrastructure for displaced persons. When decision-makers and engineers can identify such misalignments early on, they can better manage and minimize them.

Consequently, hosting communities are more likely to support the development of needed infrastructure. Figure 4.1 illustrates the context of this study.

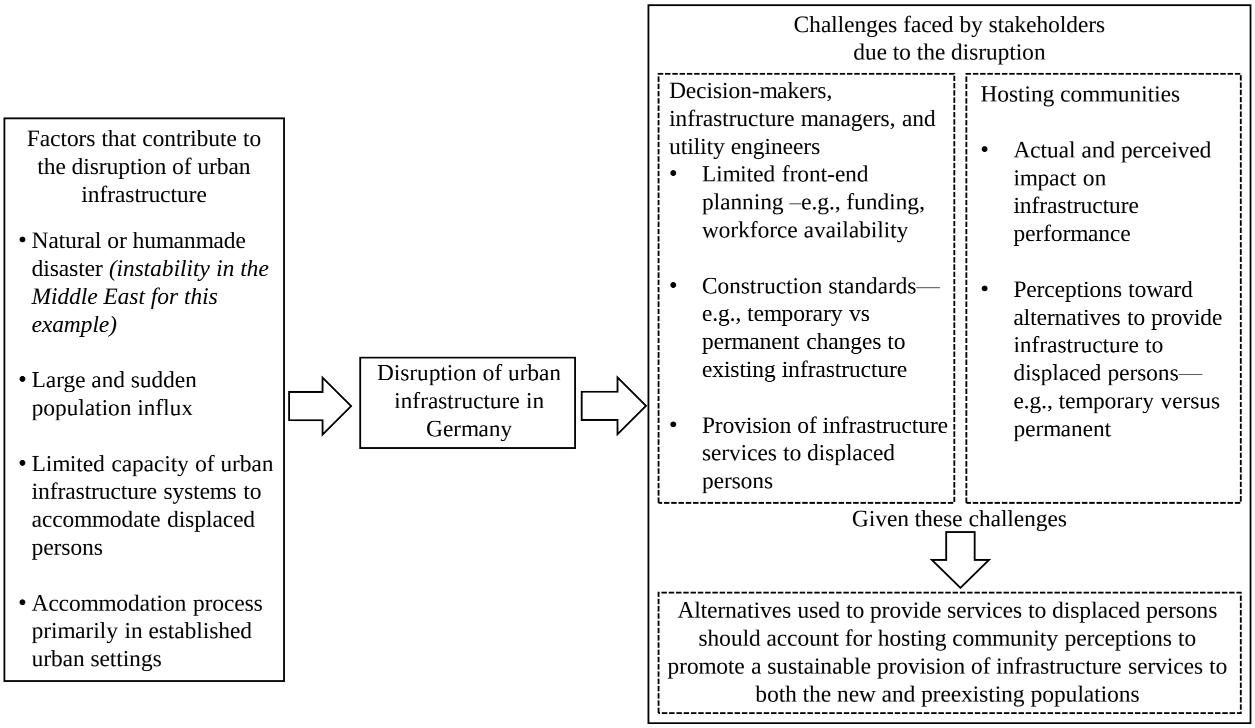

Figure 4.1. Abstraction of challenges faced by stakeholders involved in the provision of infrastructure services to displaced persons

4.2. Literature Review

This literature review is divided into three sections. The first section discusses past studies regarding the provision of infrastructure services in the context of a disaster event. The second section discusses the involvement of stakeholders during the provision of infrastructure services due to population displacement. Finally, the third section discusses existing methods to study disruptions to infrastructure systems.

4.2.1. PROVISION OF INFRASTRUCTURE SERVICES DURING A DISASTER

The frequency and severity of disasters have increased in recent years, hurricanes, earthquakes, and migratory crises have forcibly displaced millions of people around the globe (Kirbyshire et al., 2017; UNHCR 2019). This context represents a challenge regarding the provision of basic infrastructure services for communities facing a disaster or its cascading impacts. Thus, existing studies in literature can be categorized into two groups, (1) those studying the provision of infrastructure services in communities directly impacted by a disaster, and (2) those studying the provision of infrastructure services in communities hosting persons displaced from a disaster that occurred in a geographically different region.

In terms of the recovery response of communities impacted by disasters, the focus of the existing literature has been on the provision of post-disaster housing (e.g., Arneson et al., 2020) due to natural disasters such as earthquakes (e.g., Hosseini et al., 2019; Hosseini et al., 2016; Vecere et al., 2017) or hurricanes (e.g., Arneson et al., 2016; Eid and El-adaway 2017; Eid and El-adaway 2018). In terms of having a successful postdisaster recovery, the planning and coordination activities of reconstruction resources (e.g., information, financial resources, construction labor, construction materials) have been found to play a fundamental role (Arneson et al., 2017; Arneson et al., 2020; Opdyke et al., 2017). Additionally, researchers have started to study the development of sustainable disaster recovery in preparation for potential future disasters (e.g., Eid and El-adaway 2017; Eid and El-adaway 2018).

As the number of displaced populations due to human-made conflicts has rapidly increased in recent years (UNHCR 2019), researchers have also started to study the provision of infrastructure in hosting communities. Recent studies have focused on the provision of infrastructure services to displaced persons in nations with developing economies, such as

Turkey and Syria (e.g., Ahmad et al., 2017; Celik 2017; Hallak et al., 2019); however, the literature is more limited regarding studies in nations with developed economies (e.g., Faure et al., 2020; Hacker et al., 2020). It is important to emphasize this difference as typically, the accommodation of displaced persons in developing nations takes place in refugee camps, while in developed nations accommodation takes place mostly in urban settings (Kreichauf 2018). Notably, the urban context of the accommodation process leads to challenges over existing urban infrastructure in hosting communities; for instance, having adequate capacity to provide services to incoming displaced persons without disrupting services to pre-existing residents. Given this context, there is a gap in the literature when it comes to the study of the provision of infrastructure services in communities hosting persons displaced in a geographically different region.

4.2.2. Stakeholders Involved in the Provision of Infrastructure during Disaster Response

A stakeholder is an individual or organization that has a financial stake in the outcome of a project (Olander 2007), and as such, affected by the outcomes of the project (Chinyio and Olomolaiye, 2009). The literature of the management of stakeholders has been largely focused on studying stakeholders' interests and perceptions in the decision-making processes during the execution of a project (Chinyio and Olomolaiye 2009, pp 75; Doloi 2013; Mitchell et al., 1997). It has been found that a supportive interaction among stakeholders is fundamental for project success (Jepsen and Eskerod, 2009). Further, supportive interaction can be incentivized by the early engagement of stakeholders in a project (Bahadorestani et al., 2020). Conversely, when stakeholders adopt an adversarial position (i.e., opposition), project performance is negatively impacted—e.g., cost, quality (Nguyen et al., 2009; Yang et al., 2014).

As the development of sustainable projects have grown attention (e.g., Bielenberg et al., 2016; The Economist 2019; UN 2015), the literature suggests that a broader and more inclusive perspective of the concept of stakeholders is required—e.g., to include communities impacted by the development of a project (Bahadorestani et al., 2020; DiDaddaloni and Davis 2017; Jepsen and Eskerod, 2009). This discussion has received attention in the context of infrastructure projects (e.g., Di Maddaloni and Davis, 2017; Faust et al., 2013; Naderpajouh et al., 2014; Nguyen et al., 2009; Valentin et al., 2018; Xia et al., 2017); probably because of multiple infrastructure projects around the globe where performance was negatively impacted, when the role and concerns from local communities were ignored (e.g., Hurlimann and Dolnicar, 2010). For example, in 2015 in the United States, the Keystone pipeling project faced major opposition from the public, which temporarily forced the project to stop (DiChristopher. 2017).

It is important to note that when it comes to studies about the role of local communities as a stakeholder involved in the provision of infrastructure in response to a disaster, the interaction of local communities with other stakeholders involved (e.g., government, infrastructure managers) has been found to have a positive influence in the provision of infrastructure services (Mojtahedi and Oo, 2017; Pearce 2003; Sadiqi et al., 2017). Conversely, when it comes to an understanding of the role of communities being impacted by cascading impacts of a disaster occurring in a different region, the literature is more limited (Faust and Kaminsky, 2017). In the context of the large displacement of population to Germany, Kaminsky and Faust (2017) assessed the length of time hosting communities were willing to provide services to displaced persons. Kaminsky and Faust (2017) not only found that the average length of time was 2.9 years, but also that such time frame it was influenced by the context of hosting communities (i.e., geographic location and sociodemographic attributes from communities). Additionally, Araya et al. (2019) assessed the perceived impact of incoming displaced persons on German hosting communities, and the perceptions from hosting communities toward methods to provide water and wastewater infrastructure to displaced persons (Araya et al., 2020a). However, there is a gap when it comes to assessing how communities hosting displaced populations may interact with other stakeholders involved in the provision of infrastructure services to displaced persons, such as local authorities.

In summary, there are gaps in the existing disaster stakeholder management literature. First, it is important to emphasize the difference between two specific disaster contexts—communities directly impacted vs. communities experiencing secondary impacts. Communities directly impacted by a disaster may be more likely to accept necessary changes to infrastructure systems to recover from the disaster. In contrast, residents from a community that receive displaced populations but are otherwise unimpacted may not be as likely to accept changes to infrastructure systems and the corresponding disruptions to their built environment. As such, local communities hosting people due to a migratory crisis may perceive changes required to existing infrastructure as unnecessary and disruptive, which can lead to public opposition toward attempts to provide infrastructure to displaced persons. Secondly, the limited studies in the context of population displacement have been focused on the role of hosting communities in isolation from other stakeholders involved in the provision of infrastructure services, namely local authorities. By having a better understanding of hosting communities as a stakeholder, it becomes feasible for decision-makers to achieve community-supported infrastructure development needed because of displaced persons.

4.2.3. MODELING OF DISRUPTIONS TO INFRASTRUCTURE SYSTEMS

Infrastructure systems are independent networks that operate not just on their own but also collaboratively to produce goods and provide services for society (Rinaldi et al., 2001). Such collaboration entails different infrastructure systems interacting with one another—an activity known as interdependency (Rinaldi et al., 2001). Interdependencies are present when one infrastructure system impacts one or more infrastructure systems (Rinaldi et al., 2001). As such, events that directly disrupt one infrastructure system can produce cascading impacts on other infrastructure systems. For example, suppose an electrical network gets knocked out; now residents have no electricity but must also face the prospect of no drinking water if the city's pumping stations run on electricity.

In the existing literature, approaches used to model infrastructure systems disruptions are typically classified in empirical approaches, economic-theory-based approaches, network-based approaches, system dynamics approach, and agent-based simulation approaches (Hassan and Foliente, 2015; Heracleous et al., 2017; Ouyang 2014). Agent-based modeling (ABM) has been identified as a suitable approach to study complex infrastructure systems composed of decentralized actors that can interact under the same environment, and that can capture emergent system behaviors due to the interaction among the individual components or agents of the system (Sanford Bernhardt and McNeil 2008). For example, researchers have investigated the provision housing infrastructure disrupted by a natural disaster (e.g., Eid and El-adaway, 2017; Eid and El-adaway, 2018), and the provision of water and wastewater infrastructure facing population dynamics, namely long-term population decline or growth (e.g., Ali et al., 2017; Faust et al., 2017).

In the context of the water and wastewater infrastructure systems (the focus of this study) ABM provides a method that allows not only accounting for multiple, autonomous stakeholders involved in the provision of infrastructure (e.g., utilities, local communities), but also to capture potential interdependencies and reveal emergent behaviors (Berglund 2015; Faust et al., 2017; Giacomoni et al., 2013; Kandiah et al., 2019).

4.3. Methods

This section outlines the modeling approach, the model formulation, and the corresponding validation and verification processes.

4.3.1. Model Approach—Agent-Based Modeling (ABM)

Agent-based modeling (ABM) is a methodology used to model complex systems composed of autonomous decision-making entities, which are called agents (Borshchev 2013). Agents' behaviors are governed by rules and interact within their environment (Bonabeau 2002; Borshchev 2013). It is precisely through different agents' interactions within the same environment that emergent behaviors of complex systems can be observed (Macal and North, 2005). The agents' behavior is abstracted by using state charts, which represent the logic occurring during the modeling process. The behavior can be defined by multiple parameters and functions, which allows the behavior of each agent to be unique and independent. AnyLogic, an object-oriented programming tool (AnyLogic), is used to develop the proposed ABM approach.

4.3.2. Model Formulation

Figure 4.2 abstracts the components for the analysis. Two types of agent classes are included in the model: the public in hosting communities and the incoming displaced persons.

The role and decisions made by local authorities are incorporated through the rules that govern the accommodation of displaced persons. In Figure 4.2, the states surrounded by the dashed line contains the states from the hosting communities' agents. The region outside the dashed line contains the states and interactions among the displaced persons' agents during the accommodation process with the rules designed by the local authorities. The corresponding functions, parameters, and variables, and examples of decision rules of each agent are shown in Table 4.1.

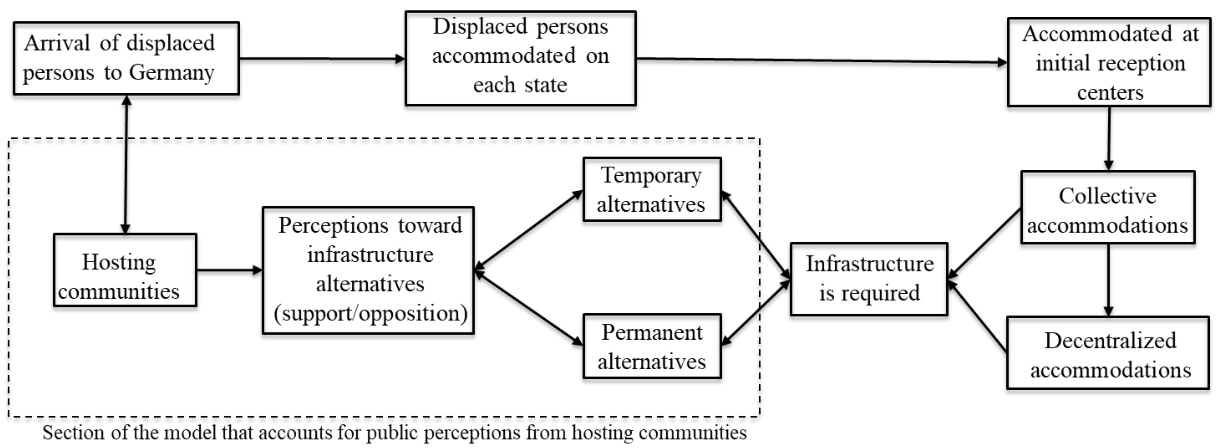

Figure 4.2. Abstraction of the model elements

Table 4.1. List of object classes present in the model and associated parameters, variables, and rules to abstract their behavior (adapted from Araya et al., 2020b)

Object classes	Function	Parameters and variables	Examples of decision rules and formulas
Hosting communities	Simulation of individual behavior in hosting communities regarding the support/opposition toward infra. alternatives	• Public support • Public opposition • Population • Geographic location • Socio-demographics	• Level of support toward infra. alternatives to provide water/wastewater services to facilities accommodating displaced persons
Incoming displaced population	Simulation of destination where displaced people are accommodated	• Number of displaced persons	• Percentage of displaced persons accommodated on each German state
Accommodation facilities	Distinguish between the different types of facilities where displaced persons are accommodated	• Number of displaced persons in each type of accommodation requiring water infrastructure	• Collective accommodations are temporary, while decentralized accommodations are more permanent
Local authorities	Decisions-made regarding where displaced people are accommodated, and which infrastructure alternative is implemented to provide water services	• Distribution system quotas • Type of facilities to accommodate displaced persons • Infrastructure alternatives: temporary or permanent	• Distributions of displaced people on the different types of accommodations • Temporary (permanent accommodations will require temporary (permanent) changes in their infrastructure

4.3.2.1. Local authorities and accommodation facilities

In response to the large number of asylum applications by displaced persons, German authorities implemented a distribution system to accommodate displaced persons at the federal level, which took into account the existing population in each state as a share of the total population in Germany—by one-third—and the state tax revenue as a share of the total revenue in Germany—by two-thirds (AIDA, 2017; Katz and Garrelts, 2016). Multiple types of facilities were used by local authorities during the accommodation process of incoming displaced persons, such as initial reception centers, collective and decentralized accommodations (AIDA, 2017). Initial reception centers accommodated displaced persons while waiting for their asylum application results, and as such, these facilities were associated more with a short-term/emergency response rather than a medium/long term response. Following a positive decision, displaced persons changed their status to refugees, and as such, were relocated to collective accommodation centers or decentralized accommodations (AIDA, 2017). Collective accommodations are temporary, while decentralized accommodations are considered permanent for displaced persons (AIDA, 2017). For instance, decentralized accommodations may include individual apartments provided by the local municipalities (AIDA, 2017).

In terms of the alternatives to provide infrastructure services, the nature of the facility dictated the type of alternative implemented by the authorities. For instance, collective accommodations were designed for temporary stays, and as such, authorities implemented temporary alternatives (e.g., installation of portable toilets), while decentralized facilities were designed for permanent stays, thus making permanent changes to provide infrastructure services (e.g., connect facilities to existing water network).

4.3.2.2. Incoming displaced persons' behavior

A population of agents named *displaced persons* was created in the model. These agents moved through the different accommodation facilities—i.e., reception centers, collective accommodations, decentralized accommodations—according to the rules developed by the local authorities. The model tracked where the displaced persons were accommodated in the three types of facilities. For example, incoming displaced persons were required to stay at initial reception centers waiting for the asylum application process approximately 6 weeks but not exceeding 6 months (AIDA, 2017). Figure 4.3 presents a statechart showing the abstracted behavior of displaced persons.

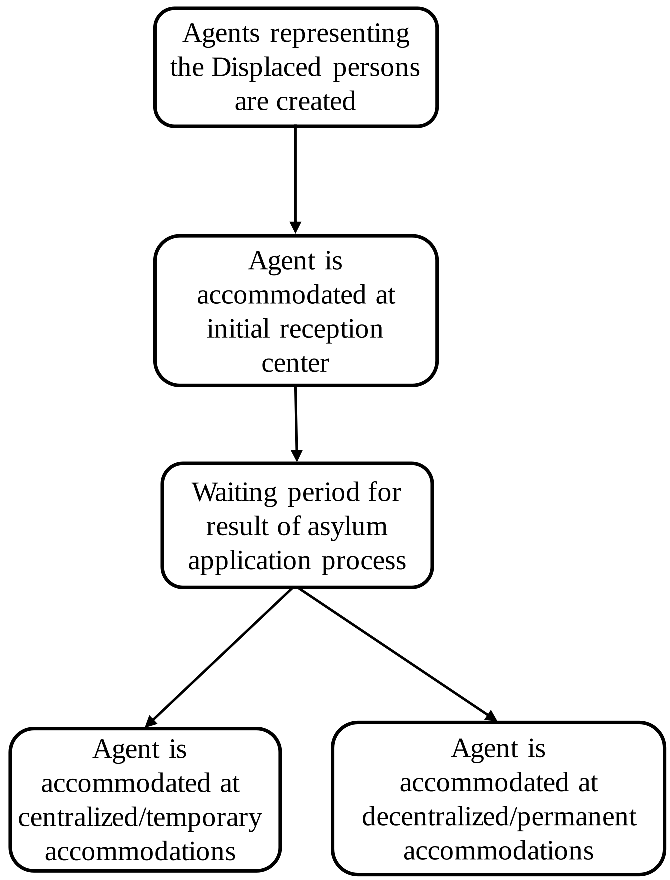

Figure 4.3. State chart governing displaced persons' agent behavior

4.3.2.3. Hosting communities' behavior

A population of agents was created to include hosting communities during the process of accommodating displaced persons. Hosting communities' agents have two different states—support and opposition toward temporary and permanent infrastructure alternatives to provide water and wastewater services to facilities accommodating displaced persons. To simulate the level of support or opposition from hosting communities' agents, econometric models, previously developed by the authors, are used. These models are based on geographic and socio-demographic parameters found to be statistically significant in how hosting communities perceived temporary and permanent changes to provide water and wastewater infrastructure to displaced persons in Germany. For more details about these statistical models, and the specific geographic and socio-demographic parameters that were found statistically significant, please refer to Araya et al. (2020a). Figure 4.4 illustrates a statechart showing the abstracted behavior of the public in hosting communities.

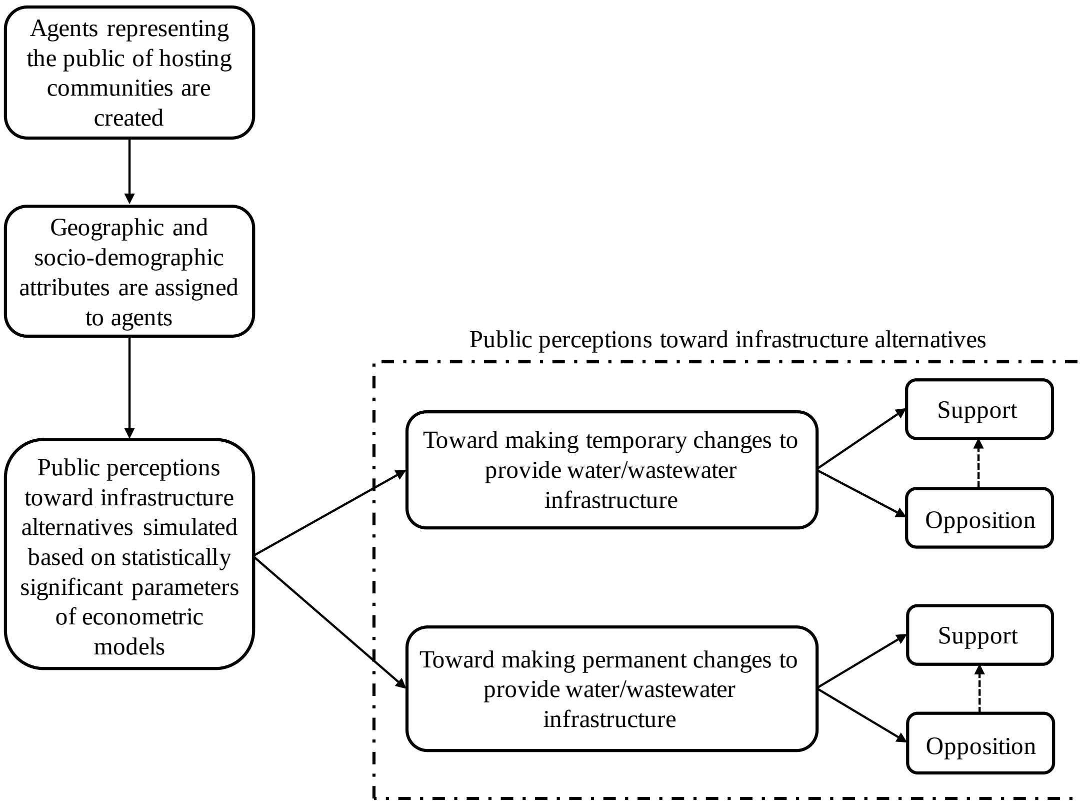

Figure 4.4. State chart governing hosting communities' agent behavior

4.3.2.4. Data sources

Data for this study come primarily from three independent sources—i.e., publicly available information and reports (e.g., UNHCR annual reports), a survey of more than 400 German, general public respondents deployed in 2016, and transcripts from 10 interviews with local authorities in Germany involved in the response to the displaced persons crisis. Publicly available data includes information about the distribution system used by German authorities to allocate and accommodate displaced populations, the three types of facilities used to accommodate displaced persons, and the numbers of displaced persons accommodated in each type of facility (AIDA, 2017). It is important to note that information from public sources may have underestimated the number of displaced persons as multiple emergency accommodations were put in place after local authorities realized their capacity to accommodate displaced persons had been exceeded (AIDA, 2017; Grote 2018).

The survey data assessed the public views of residents toward the water and wastewater infrastructure issues and alternatives to provide water infrastructure services to displaced persons, more details about the survey deployment, results, and statistics are shown on Araya et al. (2019). Data from 10 semi-structured interviews with stakeholders involved in the provision of water services to displaced persons were used to triangulate the different data sources, ensure validity, and verify model assumptions related to the decisions made by local authorities.

4.3.3. Model Implementation

In the process of accommodating incoming displaced persons in the different hosting communities, the model was first calibrated to duplicate the accommodation distribution in the German state of Berlin, for more details about this modeling process you can refer to Araya et al. (2020b). Once the model was calibrated, then it was implemented to model the accommodation process of Germany as a country. The timeframe of the simulation of the model presented in this study encompasses one year—i.e., 52 weeks.

To provide a sense of the magnitude and distribution of the displaced population arriving to Germany, Table 4.2 provides the numbers reported for 2016. Table 4.2 shows that the states of Baden-Württemberg, Bavaria, and North Rhine-Westphalia accommodated approximately 50% of all displaced persons received by Germany in 2016.

Table 4.2. Distribution of displaced persons in Germany in 2016 by federal state and type of facility (adapted from AIDA, 2017)

Year	Location (State)	Number (Percentage) of recipients	Initial reception	Collective accommodation	Decentralized accommodation
2016	Baden-Württemberg	89,856 (12.3%)	9.4%	65.1%	25.5%
	Bavaria	93,215 (12.8%)	8.2%	36.9%	54.9%
	Berlin	41,259 (5.7%)	25.1%	43.8%	31.1%
	Brandenburg	17,970 (2.5%)	8.0%	58.3%	33.7%
	Bremen	6,133 (0.8%)	3.7%	33.0%	63.3%
	Hamburg	17,466 (2.4%)	36.0%	7.0%	57.0%
	Hesse	69,874 (9.6%)	16.6%	53.4%	30.0%
	Mecklenburg Vorpommern	7,783 (1.1%)	9.4%	41.3%	49.3%
	Lower Saxony	75,401 (10.4%)	4.2%	17.9%	77.9%
	North Rhine-Westphalia	191,316 (26.3%)	18.5%	52.4%	29.1%
	Rheinland/Pfalz	31,940 (4.4%)	9.3%	14.0%	76.7%
	Saarland	1,864 (0.3%)	2.3%	41.3%	56.4%
	Saxony	28,672 (3.9%)	5.8%	59.2%	35.0%
	Sachsen-Anhalt	14,007 (1.9%)	13.5%	35.4%	51.2%
	Schleswig-Holstein	29,476 (4.0%)	7.9%	8.6%	83.5%
	Thuringia	12,007 (1.6%)	N/A	40.8%	59.2%
	Germany	***728,239 (100%)***	***12.9%***	***43.1%***	***44.0%***

Note: N/A: No number was reported for this type of facility in such location

Table 4.3 shows the average level of support from the public in German hosting communities toward the different infrastructure alternatives—these results are from the survey deployed to the German public in 2016. To illustrate the variability in the level of public support toward infrastructure alternatives among different communities, additionally, Table 4.3 shows the level of support from residents of three German states; namely, the three states accommodating the largest numbers of displaced persons in Germany.

Table 4.3. Average level of public support from German hosting communities toward making temporary or permanent changes to provide water/wastewater services to displaced persons (source: survey deployed to German hosting communities in 2016, and adapted from Araya et al. 2020a)

Location	**Water infrastructure**		**Wastewater infrastructure**	
	Temporary	**Permanent**	**Temporary**	**Permanent**
Baden-Württemberg	49%	87%	55%	74%
Bavaria	77%	87%	82%	87%
North-Rhine-Westphalia	68%	77%	63%	75%
Germany	68%	82%	68%	79%

Interestingly, Table 4.3 not only illustrates that hosting communities are more inclined to support making permanent changes to infrastructure, but also that the average level of support as a country—i.e., Germany—may not provide an accurate representation of the perceptions from communities in different German states. As such, the national average level of support toward infrastructure alternatives may not be able to capture contextual factors inherent to each community that can shape how hosting communities perceive different infrastructure alternatives, such as the state of existing infrastructure, or the interaction between residents and local utilities. While aggregated measures of public perceptions toward infrastructure provide insight into where most of the public stands, they lack to capture localized/contextual factors influencing public perceptions. The lack of granularity in the assessment of public perceptions can negatively impact the interaction between infrastructure managers and local communities by wrongfully assuming that the average represents the distribution.

Given this, and building upon exiting studies developed by the authors, statistical models developed by Araya and colleagues (2020a) are used to simulate how hosting communities perceive different infrastructure alternatives, such as the state of residence, highest level of education attained. Consequently, agents were created to have geographic and socio-demographic attributes.

The way in which the geographic and socio-demographic attributes were constructed and assigned to model's agents was by defining a probability that an agent will have a specific attribute. For instance, the values of the geographic attributes of the agents in the model mimic the geographic distribution of population in Germany (AIDA, 2017). As such, if a German state has a population that represents 20% of all population in Germany, there is a probability of 0.2 that an agent is going to be a resident from such state. Concerning the value for the socio-demographic attributes of the agents, information from the Federal Statistical Office of Germany (Destatis) was used—when available—to define how likely model's agents would have a specific attribute. However, when information about agents' attributes were not available, two sources of information were combined to make an estimation of the likelihood of having such attributes. As such, the survey results were taken into account in discussions with subject matter experts (SME) in infrastructure management and the study and modeling of public perceptions to estimate and validate values used in the model.

4.3.3.1. Metrics

The level—i.e., percentage—of support toward a specific infrastructure alternative is used as a metric to evaluate the level of agreement that hosting communities show toward a specific alternative. By knowing which alternatives preferred by hosting communities, a comparison with the actual distribution of displaced persons accommodated by facilities can be made. This comparison shows how aligned the decisions made by local authorities are with the perceptions from hosting communities. This metric is used as having the support from hosting communities to make necessary changes to existing infrastructure is one of the main challenges in providing infrastructure services to displaced persons (Faust and Kaminsky 2017). Figure 4.5 illustrates (mis)alignment between local authorities and hosting communities regarding alternatives to provide infrastructure to displaced persons.

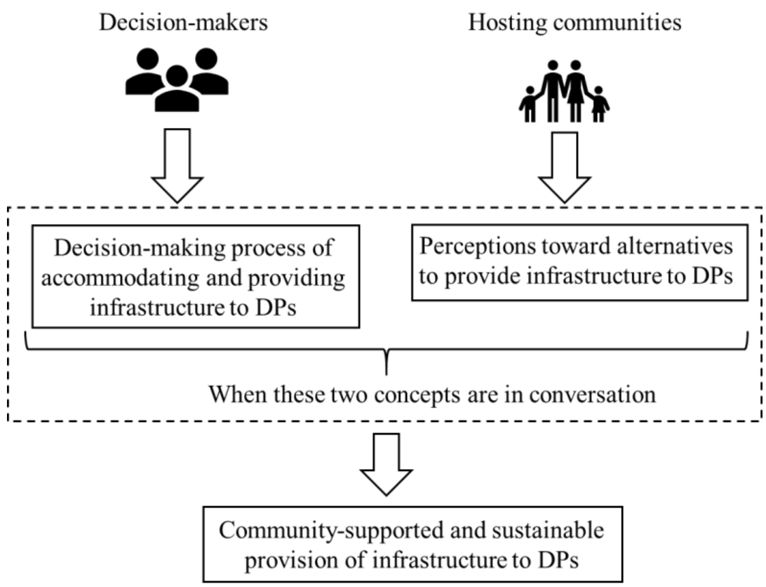

Figure 4.5. Representation of decision-makers and hosting communities as stakeholders to provide sustainable infrastructure to displaced persons (DPs)

4.3.3.2. Case Study

In 2016, Germany was the recipient of more than 700,000 asylum applications, primarily due to the political instability in the Middle East. This context makes of Germany an excellent candidate in which to implement the proposed framework. Table 4.4 shows the parameters and variables and values used in the case study.

Table 4.4. Model's parameters and variables values used in the case study

Parameter/Variables	Value	Justification/References
% of displaced persons accommodated at initial reception centers	12.9%	Percentage of displaced persons accommodated at initial reception centers in 2016 (AIDA, 2017)
% of displaced persons accommodated at collective accommodations	43.1%	Percentage of displaced persons accommodated at collective accommodations in 2016 (AIDA, 2017)
% of displaced persons accommodated at decentralized accommodations	44.0%	Percentage of displaced persons accommodated at decentralized accommodations in 2016 (AIDA, 2017)
% of public support/ opposition toward making temporary changes to infrastructure	from 0 to 100%	Econometric models modeling public perceptions toward making temporary changes to water/wastewater infrastructure (Araya et al., 2020)
% of public support/opposition toward making permanent changes to infrastructure	From 0 to 100%	Econometric models modeling public perceptions toward making permanent changes to water/wastewater infrastructure (Araya et al., 2020)
Time displaced persons wait at the initial reception centers	Uniform distribution (6 to 24 weeks)	Waiting time varied between 6 weeks and 6 months (AIDA, 2017)
Time displaced persons wait at the collective accommodation	Uniform distribution (4 to 8 weeks*)	Time period dependent on each facility (AIDA, 2017).
Geographic parameter—i.e., state of residence.	Baden Wurttemberg (13.3%). Rhineland-Palatinate (4.9%). Saxony (4.9%). North-Rhine Westphalia (21.7%). Bavaria (15.7%).	Geographic parameters identified by Araya et al. (2020). Percentage of population living in German states (AIDA, 2017)
Socio-demographic parameters**	Employment status is employed by a salary (60%) Car ownership and use (84.3%) Highest education attained is high school (22%)	Information of socio-demographic attributes extracted from: Federal Statistical Office of Germany (Destatis n.d.), and Survey deployed to German hosting communities (Araya et al. 2019; Kaminsky and Faust, 2017).
Perception change rate from opposition to support	Uniform distribution (0.01-0.03)	Perceptions are dynamic and can change with new information and events (Dowler et al., 2006; Yang and Faust 2019)

*: This value was set during the calibration of the model to replicate the actual distribution of displaced persons on the different types of facilities in 2016, as indicated in AIDA (2017).
**: Due to space limitations the complete list of values used for the socio-demographic attributes of hosting communities' agents is provided in the appendix section.

4.3.3.3. Scenarios

Two scenarios are explored in this study. The first one is simulating the perceptions from the public assuming the level of support toward infrastructure alternatives does not change over time. The second scenario, however, simulates perceptions from the public as dynamic, and as such, residents can move from a status of public opposition to public support. This second scenario is based on the existing acknowledgement in the literature that public perceptions are dynamic and may change with new information, events, and social interaction among the public (e.g., Osman et al., 2019; Yang and Faust, 2019). In practicality, the change in perceptions from residents aims to represent the implementation of a public policy to increase the level of support from local communities as a form of integration into the decision-making process.

4.3.4. Verification and Validation

Steps to ensure that the model was verified and validated include conceptual model validation, computerized model verification, operational validation, and data validity (Sargent 2004). The conceptual model validation occurred as the logic followed by the agents is based on different data sources (publicly available information, survey, and interviews). The computerized model verification was done by evaluating whether the distribution of displaced persons on the different accommodations was aligned with the actual distribution numbers in one German state—i.e., Berlin (Table 4.2); then, the model was expanded to represent the accommodation process at the national level. Finally, the model's assumptions were validated based on information collected through 10 interviews with local utilities and government representatives as well as through conversations with subject matter experts (SMEs) with experience in modeling public perceptions, infrastructure management, and systems modeling.

4.3.5. LIMITATIONS

As with any study, limitations exist with this one. Data availability regarding the accommodation process of displaced persons was scarce and incomplete, limiting our understanding of the impact of population displacement on hosting communities. Moreover, limited data constrains not just the development of models but also their comparison with actual data. However, when it comes to modeling infrastructure provision to displaced persons, the authors claim that it is even more important to take initial incremental steps. Hopefully, these initial models will spark discussion and more data collection and thereby improve our understanding of the provision of infrastructure to displaced persons in hosting communities.

A second limitation arises from using a cross-sectional survey to represent public perceptions from hosting communities. Perceptions are dynamic, changing with new information and events. To minimize the influence of this limitation, scenario two included a change in perception among the hosting communities over time. Finally, the framework is implemented in a specific region—Germany. Yet this framework is adaptable to other communities. It demonstrates how local authorities that are providing infrastructure services to displaced persons interact with hosting communities and their perceptions of alternatives to such provision.

4.4. Results

During the accommodation process of incoming displaced persons in Germany as shown in Figure 4.6, most incoming displaced persons were initially accommodated at initial reception centers but over time displaced persons were granted the status of asylum seeker/refugee and moved to centralized or decentralized facilities.

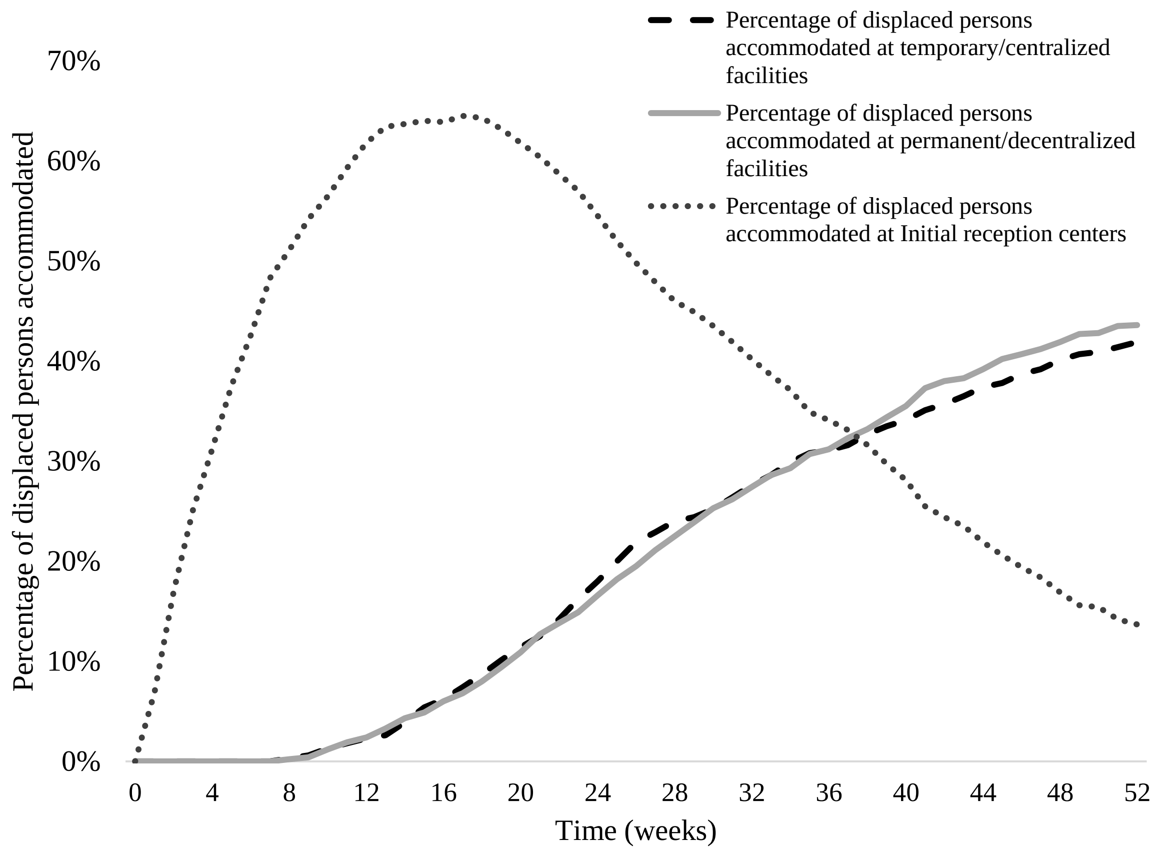

Figure 4.6. Simulation of the accommodation of displaced persons in Germany in 2016

Table 4.5 shows the level of support and opposition simulated with the agent-based model for Scenario 1, in which the level of support and opposition among hosting communities does not change throughout time. These results show that residents of hosting communities are more likely to support infrastructure services to displaced persons making permanent changes to existing systems as compared to temporary changes. As a reference, Table 4.5 shows the actual levels of support and opposition obtained from the survey deployed in 2016. Table 4.5 shows that the model provides similar results to the actual perceptions from hosting communities.

Table 4.5. Simulated and actual level of support and opposition from hosting communities toward making temporary/permanent changes to provide water and wastewater to displaced persons

Public perceptions from hosting communities	Water infrastructure		Wastewater infrastructure	
	Temporary	Permanent	Temporary	Permanent
Simulated perceptions (Modeled output)				
Support	71%	89%	66%	77%
Opposition	29%	11%	34%	23%
Surveyed perceptions (Actual output)				
Support	68%	82%	68%	79%
Opposition	32%	18%	32%	21%

Figures 4.7 and 4.8 show the results of simulating Scenario 2 of how German hosting communities perceive making temporary/permanent changes to provide water and wastewater, respectively. In both figures, the solid lines represent how the level of support toward the infrastructure alternatives increased over time due to the implementation of a public policy to integrate local communities. The increased level of support then captures the potential effects of such public policy. In both figures, it can be observed that due to the simulated changes from opposition to support, the level of support among infrastructure alternatives increased approximately by 10%.

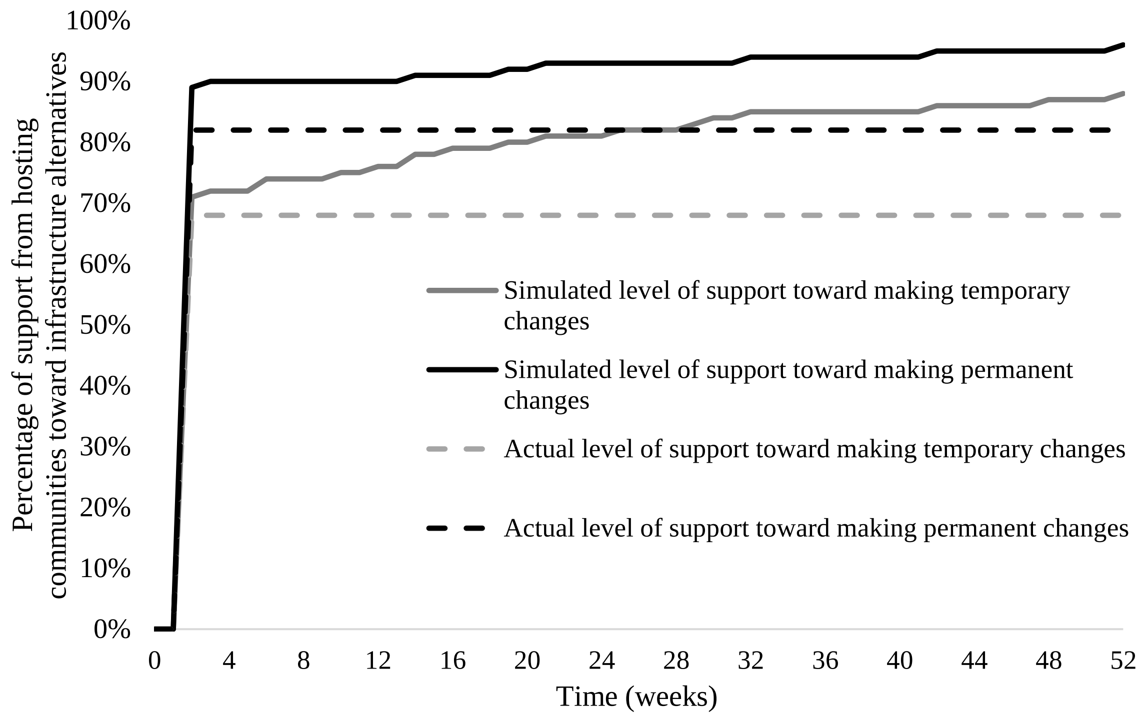

Figure 4.7. Simulated and actual level of public support toward making temporary/permanent changes to water infrastructure

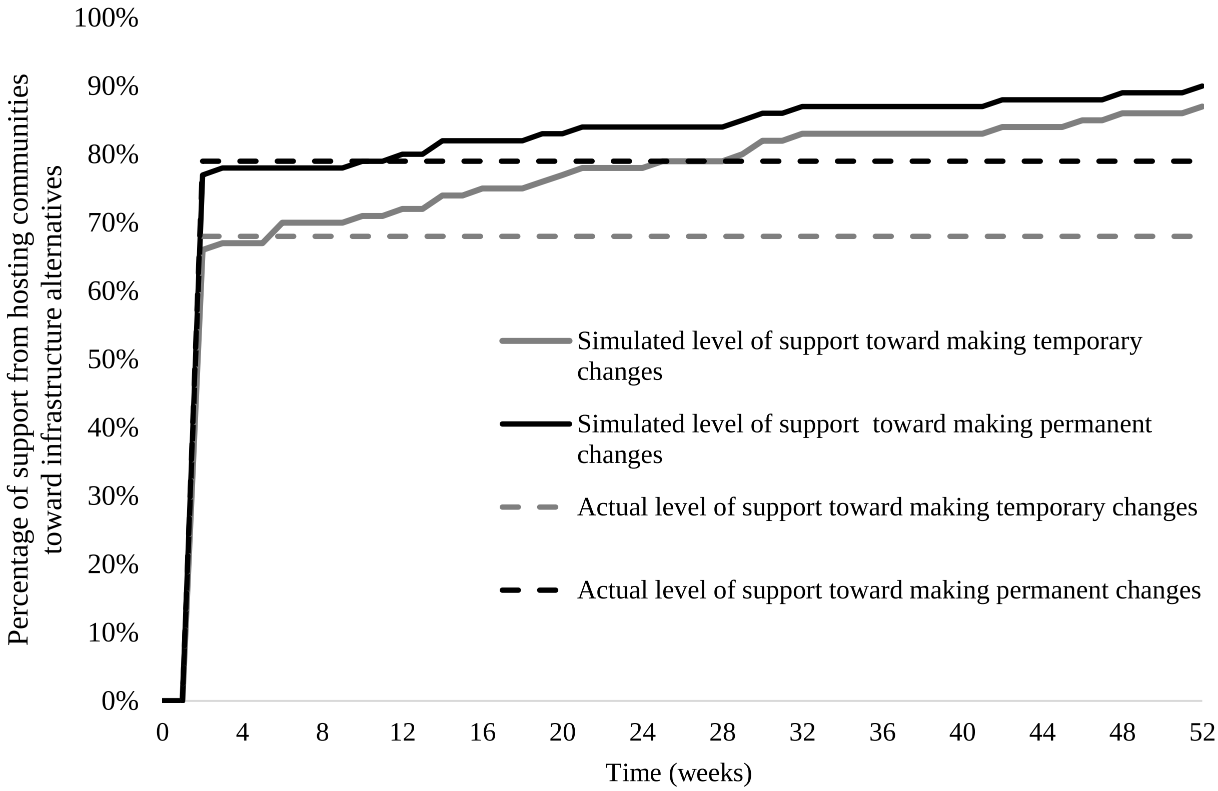

Figure 4.8. Simulated and actual level of public support toward making temporary/permanent changes to wastewater infrastructure

4.5. Discussion

The proposed framework promotes the idea of decision-makers taking into account public perceptions of infrastructure alternatives. Typically, the provision of infrastructure to displaced persons involves solely local authorities (e.g., decision-makers, utility engineers, and managers). However, as the accommodation process of displaced persons has started to occur in urban settings, residents from hosting communities may be impacted by the provision of infrastructure to displaced persons. This potentiality elevates the role of hosting communities. Consequently, local authorities and engineers should account for such a role during the decision-making process. The proposed framework allows us to look at the decision-making process followed by local authorities while also accounting for public perceptions toward infrastructure alternatives to provide such infrastructure to displaced persons. Thus, in seeking alignment with alternatives that hosting communities support, decision-makers may be able to adapt alternatives early on in infrastructure planning and development.

Our results showed that hosting communities were more likely to support infrastructure alternatives that involve making permanent—not temporary—changes (Table 5; Figures 7-8). Local authorities, though, used facilities requiring temporary or permanent changes in similar percentages (Figure 6). This result underscores the misalignment between types of alternatives used by local authorities and the level of support from hosting communities toward using such alternatives. Such misalignment is exemplified in a comparison of Bavaria with Baden-Württemberg and North Rhine-Westphalia. To accommodate displaced populations in Bavaria, local authorities used mostly decentralized/permanent facilities (Table 2). This action aligned well with local residents who largely supported making permanent changes (Table 3). To house displaced persons in Baden-Württemberg and in North Rhine-Westphalia, local authorities mainly used centralized/temporary facilities (Table 2). This action aligned poorly with local residents who, like their Bavarian counterparts, largely supported making permanent changes (Table 3). Decision-makers and local authorities should make it a goal to identify and minimize these misalignments during the early stages of infrastructure development. As discussed in the literature, when officials try to implement unpopular projects to provide infrastructure to communities, the results can be negative, such as higher costs, lower quality, or even project suspension (e.g., Faust et al., 2016; Valentin et al., 2018; Yang et al., 2014). This study contributes by providing a framework with which potential misalignments may be identified. As such, it serves as a practical contribution for engineers and decision-makers in charge of providing infrastructure services in urban settings.

The fact that hosting communities generally support permanent alternatives may indicate the perception that meeting the infrastructure needs of the displaced people will help ensure that their own are met. Conversely, hosting communities may perceive temporary fixes as helping the infrastructure needs of only the displaced, while neglecting the those of the hosting communities. This difference in perceptions between making temporary and permanent changes was also captured on open-ended questions from the survey deployed to German hosting communities: *"I think a temporary solution is sufficient."* And *"I would determine the emerging consumption by the number of planned refugees, in the short term I would support that through a mobile supply but long term I would adjust the infrastructure correspondingly."* These results are in conversation with existing studies that found a relationship between the impacts of rapid population growth and how hosting communities perceive their built environment should be adapted to such impacts (Islam et al., 2014). Once authorities are aware of which infrastructure alternatives attract support, they might seek interaction with the communities to explore why communities support one alternative and not another.

When the two scenarios presented in this study are compared, scenario one can be understood as the baseline of the level of support from hosting communities toward different alternatives; scenario two can be understood as tracking evolving perceptions after a public policy is implemented—with support increasing by roughly 10% (Figures 7-8). In the literature, it is recognized that public perceptions are dynamic and, with new events and information, may change over time (de Franca Doria, 2010; Dowler et al., 2006; Yang and Faust, 2019). Now how public policies impact those perceptions of infrastructure alternatives is an area not well researched. Given this context, the simulated public policy in scenario two is defined in terms of the rate at which residents change from opposing infrastructure alternatives to supporting them (Table 4). Despite the existing limitations in the literature, developing a framework that captures how perceptions may change with time is understood as an incremental contribution to the study of public perceptions from communities in their interaction with infrastructure systems. Furthermore, we expect that by developing frameworks and models, researchers will generate more data and knowledge of how public perceptions of infrastructure alternatives evolve over time.

For local authorities and decision-makers, it is both a challenge and an opportunity to make decisions while including a hosting community's perceptions of infrastructure alternatives. It is a challenge in the sense that, based on contextual conditions, the alternatives may differ among communities. An alternative that one community may support may be opposed by another. It is an opportunity in the sense that alternatives that are supported are more sustainable (Faust et al., 2016). Similarly, providing infrastructure services may be done more effectively if the process involves the community (Crawford et al., 2013). Accounting for the influence of community perceptions could smooth the integration of displaced populations, giving rise to less isolation of displaced persons (Seethaler-Wari, 2018).

One obstacle, though, to local authorities including hosting communities is the simple lack of data and information on how to go about this. Indeed, more data is necessary to understand the role of local communities during the development of urban infrastructure. For example, we still need to understand what level of public support is sufficient to ensure the successful implementation of infrastructure projects. We need to know what type of efforts/policies local authorities can implement to increase the level of support among communities. As a research community, we need more data to be collected to understand how efforts and policies from authorities can maximize their impacts on incorporating communities, so authorities can decide when it is necessary to deploy such efforts and resources.

To integrate and collect data about hosting communities, researchers can adopt multiple approaches. Utilities, for example, could regularly deploy surveys asking residents about their perceptions of certain infrastructure issues. Local authorities—e.g., utility managers—could keep in contact with communities about existing problems and issues with urban infrastructure services. Ultimately, updated sources of information from hosting communities should be permanently recorded and included in the decision-making process, so when unexpected disruptive scenarios occur—e.g., massive and unexpected migration—infrastructure managers and utilities can leverage such information in advance to ensure that alternatives to be developed are in conversation with the views and concerns of hosting communities.

4.6. Conclusions

This study proposed and illustrated a modeling framework to identify points at which hosting communities are not in alignment with local authorities as the latter decides how best to provide water and wastewater infrastructure to displaced persons. The proposed framework represents an incremental step in encouraging local authorities to include hosting communities in the decision-making processes of selecting infrastructure for displaced populations. A contribution to literature is made to disaster stakeholder management by developing a framework capable of identifying potential misalignments between hosting communities and local authorities. The framework also points the way to how local authorities might achieve alignment by taking into account the perceptions of hosting communities.

The framework captures how hosting communities perceive different alternatives using contextual parameters—geographic and socio-demographic parameters—from hosting communities. A practical contribution of this study is that the proposed framework identified misalignments between alternatives used by local authorities and alternatives supported by hosting communities. Therefore, it is recommended that, in the early stages of developing infrastructure alternatives, local authorities and engineers take into account hosting communities' perceptions. This way misalignments may be minimized. As such, authorities can implement more sustainable and community-supported infrastructure alternatives.

Future studies should build upon the proposed framework by collecting more data and expanding the number of stakeholders included in the model. When it comes to the actual usage of water and wastewater infrastructure, for example, if local authorities consider the displaced persons to be stakeholders, then they will be equipped to facilitate the incorporation of cultural differences between hosting communities and displaced persons. To expand our understanding of hosting communities as a stakeholder, a valuable source of information could be qualitative methods, such as interviews with hosting communities. Another avenue of future studies may be to expand to other urban infrastructure systems, such as transportation. In doing so, interdependency analyses can be implemented to assess the interaction between authorities of multiple urban infrastructure systems.

CHAPTER 5. CONCLUSIONS

5.1. Dissertation Overview

This dissertation sought to understand how hosting communities provided infrastructure services to both displaced persons and pre-existing residents during the European Refugee Crisis during 2015 and 2016. Enabling the study, statistical and qualitative analyses were coupled to analyze data gathered in 2016 in Germany— the European country receiving the highest magnitude of asylum seekers at the time. This dissertation found that local authorities and decision-makers in charge of the provision of urban infrastructure to displaced persons should incorporate hosting communities as a valid stakeholder when deciding how to provide such services; accounting for how hosting communities perceive infrastructure alternatives may assist decision-makers to minimize sources of public opposition during the implementation of such alternatives. Additionally, public perceptions from hosting communities were found to be influenced by contextual factors, such as geographic and socio-demographic attributes. As such, alternatives not only showed different levels of support and opposition depending on the local context, but also misalignment between alternatives used by local authorities and alternatives publicly supported by hosting communities. Finally, the framework developed enables an increased sustainability of interactions of and outcomes between local authorities and community members by comparing the alternatives implemented with corresponding levels of public support.

5.2. Contribution to the Body of Knowledge

This work contributes to the body of knowledge through understanding hosting communities as a stakeholder in the provision of urban infrastructure. Select contributions include:

- Contributions to complexity theory by increasing the understanding of urban infrastructure as a complex adaptive system (Little 2002; Rinaldi et al., 2001). Complexity is defined here as the interaction among system elements that yields to emergent behaviors that cannot be explained solely by the understanding of system elements alone (Bonabeau 2002; Brown et al., 2004). This previously unexplored complexity is approached through the lens of extreme events brought about via population dynamics—i.e., sudden, unexpected influx of population—and its cascading impacts on the provision of infrastructure to displaced populations in otherwise unimpacted hosting communities. Namely, residents of hosting communities perceiving the provision of infrastructure to displaced persons as a disruption to their built environment represent an exogenous impact that further stresses existing interdependencies, and creates new interdependencies such as organizational links between local authorities and hosting communities in the disaster response. Implementing quantitative and qualitative techniques, helped to understand otherwise undetected complexity in the interaction between hosting communities and local authorities. Thus, this also contributes to reducing the epistemic uncertainty—i.e., the uncertainty that comes from the lack of knowledge—in the context of the interactions of our physical engineering systems and the social structure in which they operate. Extreme events like the one studied in this dissertation can be used as an opportunity to learn and improve our understanding of how to provide sustainable urban infrastructure.

- Chapter 2 shows that in the context of the refugee crisis, the geographic scales influence public perceptions of hosting communities. Hosting communities perceived the impact of displaced persons on urban infrastructure systems similarly within city and national scales, but differently across. Furthermore, the geographic and socio-demographic drivers of hosting communities' perceptions were found to have considerable heterogeneity, which emphasizes the influence of the context of hosting communities on how disruptions are perceived at the city and national scales. This contribution is framed in the literature of the place-attachment theory (Clarke et al., 2018; Devine-Wright, 2009), as communities' perceptions interact with place-attachment sentiments from their residents (Devine-Wright, 2013; Rollero and De Piccoli, 2010). The existing literature focused on the effects of disruptions at the household or neighborhood level (Lewicka, 2011); this dissertation contributes by expanding the assessment of disruptions at higher scales of analysis, namely city and national levels.
- Chapter 3 indicates that it is necessary to understand the role of hosting communities as a stakeholder involved in the provision of urban infrastructure to displaced populations. This finding contributes to the literature of disaster stakeholder management (Crawford et al., 2013; Mojtahedi and Oo, 2017; Pearce, 2003). Specifically, by identifying and analyzing a stakeholder otherwise typically overlooked —i.e., hosting communities— during the management of urban infrastructure projects. Additionally, Chapter 3 shows that contextual factors—geographic and socio-demographic attributes—play a fundamental role in shaping

how hosting communities perceive infrastructure alternatives. This finding is framed in the context of community-based research (Israel et al., 1998; Minkler, 2005; Rickenbacker et al., 2019) as contributes by identifying specific attributes that are significant in the involvement of hosting communities in the decision-making process of providing urban infrastructure to displaced persons.

- In Chapter 4, a framework was presented to explore how public perceptions from hosting communities toward infrastructure alternatives compared with alternatives used by decision-makers. This framework contributes to the literature of disaster stakeholder management (Crawford et al., 2013; Mojtahedi and Oo, 2017) by revealing and understanding existing misalignments between decision-makers and hosting communities as stakeholders. This contribution provides valuable insights about how these two stakeholders interact in a context of a disaster, and as such, it enriches the process of managing stakeholders in the context of a disaster.

5.3. Contribution to the Body of Practice

Select contributions of this work to the body of practice are as follows.

- This dissertation brings increased awareness to engineers, local authorities, and decision-makers about the role of hosting communities in the process of providing urban infrastructure to displaced persons. Decision-makers should account for contextual conditions that influence (1) how hosting communities perceive the disruption from displaced persons on urban infrastructure, as well as (2) different infrastructure alternatives used in the provision of services, such as geographic and socio-demographic attributes from hosting communities. The contextual conditions of each hosting community—captured through geographic and socio-demographic attributes—was revealed to consequentially lead to different levels of support or opposition regarding perceived disruptions and infrastructure alternatives. Thus, this reinforces the importance to plan and develop alternatives that are in conversation with the interests and concerns of preexisting residents. Through doing so, sustainable infrastructure alternatives with the input from hosting communities can be implemented, minimizing potential sources of public opposition from hosting communities.

- Statistical modeling approaches were implemented to identify contextual factors influencing perceptions from hosting communities toward infrastructure-related topics. Moreover, when coupled with qualitative analyses, a more comprehensive understanding of hosting communities was reached, revealing new trends and insights from hosting communities. The combination of multiple information sources—both quantitative and qualitative—proved to enrich the understanding of hosting communities. These tools can be implemented to better understand other stakeholders involved in the provision of urban infrastructure, such as utility mangers and engineers.
- A model was developed that can integrate hosting communities into the decision-making process of providing urban infrastructure. Notably, using a modeling tool to understand the interaction of stakeholders in the decision-making process presents an advantage for practitioners as experimentation in the virtual work—the model—is risk-free and less expensive compared with interventions in real infrastructure systems. Furthermore, modeling tools allow creating multiple scenarios in advance that may enrich the planning and preparedness of decision-makers when facing similar scenarios in the future.

5.4. Future Research

As explored in this dissertation, it is necessary to have a better understanding of hosting communities as a stakeholder involved in the provision of urban infrastructure to displaced persons. As such, future research could explore multiple avenues to do so. Alternative data-collection methods to further explore the reasons of the statistical trends identified in this dissertation can be explored. Data-collection methods that are proposed to be used are semi-structured interviews with residents of communities hosting displaced populations. From a more practical standpoint, future studies could consider how existing project delivery systems—e.g., public-private-partnerships (PPP) or integrated project delivery (IPD)—can be used to leverage the incorporation of public perceptions of hosting communities during the different stages of infrastructure projects, such as planning, design, construction, and maintenance. Notably, this dissertation was focused on the response of hosting communities in Germany due to the referred refuge crisis in Europe. However, hosting displaced populations is not a problem exclusive to a specific region of the world; it is a global issue. As such, it is recommended to explore other areas hosting displaced populations to assess possible cultural similarities and differences amongst hosting communities and displaced persons. For example, exploring how hosting communities react to displaced persons in developing nations where presumably infrastructure systems are less developed and complex compared with developed nations. Another interesting avenue for future work, it would be to explore how hosting communities interact with displaced populations not only during a short/medium-term response but also during a long-term accommodation process occurring during a protracted crisis. The long-term context may open the possibilities to combine the needs of providing infrastructure to displaced persons with the needs for infrastructure development of hosting communities. As such, alternatives that are mutually beneficial in the long-term for both populations could be pursued.

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VITA

Felipe Andres Araya Araya received his bachelor's and master's degree in Civil Engineering from Federico Santa Maria University, he was awarded a Fulbright/Conicyt scholarship to pursue his doctoral studies in Civil Engineering at The University of Texas at Austin in 2016. During his doctoral studies, for his dissertation, Felipe studied the impact of sudden and large population influxes on urban infrastructure from the perspective of hosting communities. Namely, understanding how the disruption from a large population influx was perceived by hosting communities, and how hosting communities perceived different alternatives to provide infrastructure to additional populations. Additionally, Felipe was involved in research projects studying human infrastructure interactions in different contexts. For example, understanding the difference between perceived and actual water conservation at the household level, studying subjective and objective metrics to assess energy poverty, and assessing how underserved communities in informal settlements interact with their limited infrastructure. Following the completion of this Ph.D., Felipe Araya will begin working for the Federico Santa Maria Department of Civil Engineering in Valparaiso, Chile.

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